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July – September 1955

Quarterly Journal

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SURVEYING AND MAPPING is the official journal of the Congress and is published quarterly during the months of March, June, September, and December. The Congress welcomes articles and interesting news items for publication in its journal. Manuscripts should be sent to the Chairman of the Publications Committee.

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SURVEYING AND MAPPING

Editors-in-Chief
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A QUARTERLY JOURNAL
DEVOTED TO THE ADVANCEMENT OF THE SCIENCES
OF SURVEYING AND MAPPING

Volume XV, No. 3
July–September 1955

PUBLISHED BY THE
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The Surveyor's Notebook

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"A Bit More Mauka . . . A Few Feet Makai"

"Surveys in Hawaii introduce many new features to a surveyor trained on the mainland," says Russell Brinker, Head of the Department of Civil Engineering at Virginia Polytechnic Institute.

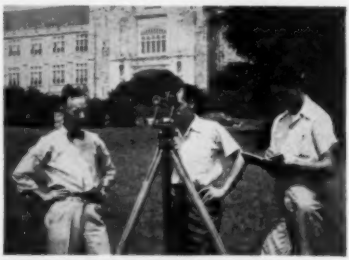
"The ancient land system divided an island roughly into several *mokus* (districts). Each *moku* was split into *ahupua'as*, pie-shaped pieces extending from ocean to mountain top and varying considerably in area.

"Theoretically, each *ahupua'a* contained a *kai* (sea fishery), a stretch of *kula* (upland) and some *kuahiwi* (forest and mountain land). Thus, the ruling chief and his people could get fish, taro and wood from their own land holdings in the Islands.

"To trace old deeds, today's surveyor must be able to read descriptions in a 12-letter Hawaiian alphabet. Simple terms like North and South are frequently discarded in favor of visual directions. What, then, could be easier than to send a rodman a bit more *mauka* (mountainward) or a few feet *makai* (oceanward)? Or to tell the chainman to move Diamond Head-way or Punchbowl-way?

Triangulation stations like this are common in Hawaii.

"In the mid-'30's, I surveyed small parcels in the Islands for the Government, so that portions could be taken out of rice production. Standard practice was followed the first half day by measuring angles at corners, and lengths along dike sides of the flooded rice paddies. Since ties between adjacent ownerships and exact areas were not needed, a faster, less accurate method seemed necessary.



Prof. Russell Brinker (left) instructs students at VPI in the use of the transit. The instrument is one of 25 Gurley transits and levels owned by VPI.

"So we set up near the estimated center of an individual farm on a paddy bank. Two rodmen started at diagonally-opposite corners and moved clockwise around the field. Stadia distances and azimuths from an arbitrary reference line were read on the two rods in alternate order and recorded.

"As soon as all corners had been sighted, we set up in the next field and repeated the process. Readings were plotted later and areas obtained by planimeter.

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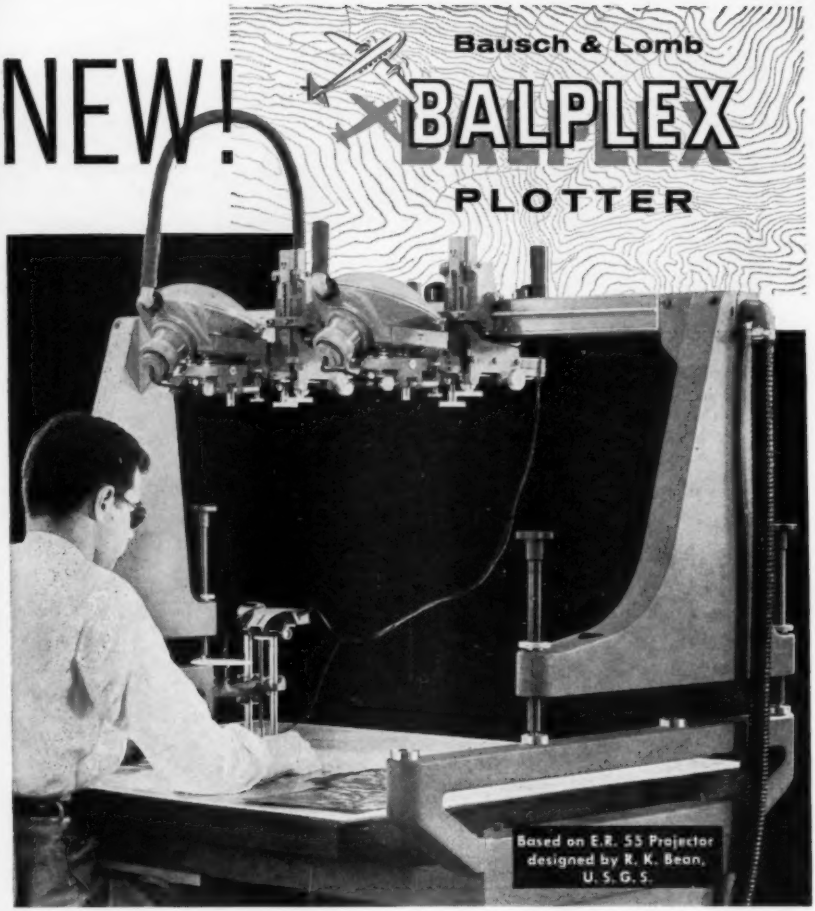

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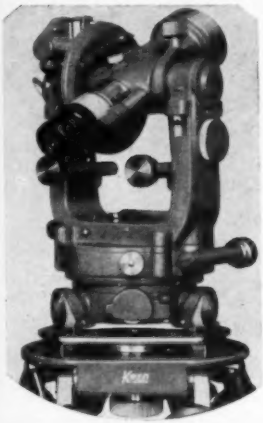

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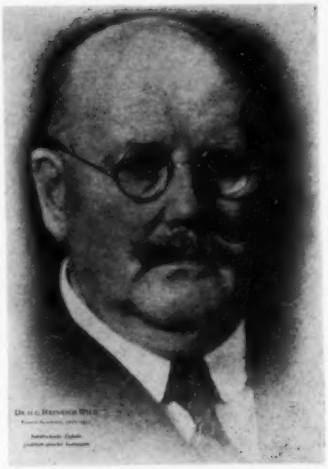

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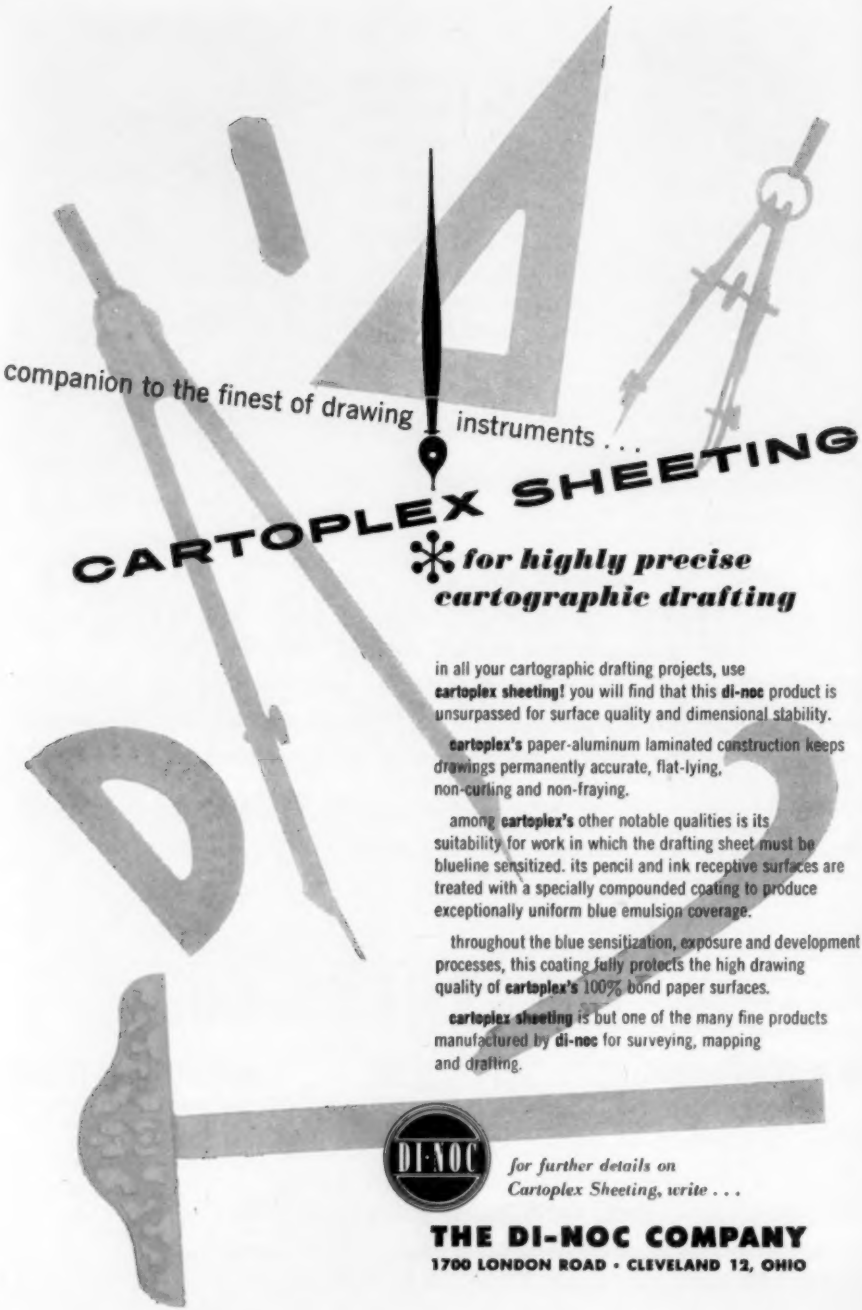

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Fifteenth Annual Meeting Resolutions Presented to Government Officials

ACSM OFFICERS PRESENT RESOLUTIONS TO FEDERAL OFFICIALS

Photograph taken in the office of the Secretary of Commerce, shows, *left to right*: Secretary Dix, ACSM; President Higbee, ACSM; the Honorable Sinclair Weeks, Secretary of Commerce; and Rear Admiral R. F. A. Studds, Director, USC&GS. (Admiral Studds is a Past-President of ACSM.)

On June 22, 1955, ACSM formally presented resolutions from the Fifteenth Annual Congress to responsible officials as directed. President Higbee and Secretary Dix made personal presentations to the Secretary of Commerce, the Director of the U. S. Coast and Geodetic Survey, the Commissioner of Public Roads, and the Executive Secretary of the American Association of State Highway Officials. The resolutions were also conveyed to the President of the United States, at the White House executive offices, by special messenger. On this same day the resolutions were directed to highway officials of all States and Territories by mail, and to Congressional Committee Chairmen by mail or messenger. It can be reported that all resolutions were well received and indications are that serious consideration will be given to them.

—Walter S. Dix
Executive Secretary, ACSM

Mapping and Photogrammetry Save Dollars

Assembled and edited by WALTER G. STONEMAN

CHAIRMAN, COMMITTEE ON MAP USE, ACSM

EDITOR'S NOTE.—The following collection of major policy statements and specific illustrative examples of the value of maps and aerial photographs was assembled by Mr. Stoneman as a companion work to his discussion of "Public Appreciation and Use of Maps and Surveys," which was presented at the Fourteenth Annual Meeting of ACSM, March 1954. Although there is little need to persuade regular readers of SURVEYING AND MAPPING of the value of maps and surveys, there is real need for a convenient compilation of authoritative statements on the subject for ready use in promoting the cause of good mapping in other quarters. This need is met in a most thorough manner by Mr. Stoneman's compilation.

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Part I. Policy Statements

1. EXTRACTS FROM "MODERN CARTOGRAPHY," A UNITED NATIONS PUBLICATION

Report of the Committee of Experts on Cartography

Economic and Social Council resolution 131 (VI) of 19 February 1948 on Coordination of Cartographic Services of Specialized Agencies and International Organizations:

Whereas, accurate maps are a prerequisite to the proper development of the world resources which in many cases lie in relatively unexplored regions;

Whereas, such maps facilitate international trade, promote safety of navigation, both in the air and in the sea, and provide information required for the study of measures of peaceful adjustment under Chapter VI of the Charter, and for the application of security measures contemplated in Chapter VII of the Charter;

Whereas, the coordination of the cartographic services of the United Nations and specialized agencies, as well as those of the Member Nations, will result in significant economies in cost, time, and personnel, and will contribute to the improvement of cartographic techniques and standards; and

Whereas, several Member Governments have already indicated their interest in a coordinated programme of international cartography;

The Economic and Social Council *therefore* recommends:

1. That the Member Governments stimulate the accurate survey and mapping of their national territories;

2. That the Secretary-General take appropriate action, within the limits of budgetary availabilities: (*a*) To further such efforts by promoting the exchange of technical information and other means, including the preparation of a study on modern cartographic methods and development of uniform international standards; (*b*) To coordinate the plans and programmes of the United Nations and specialized agencies in the field of cartography, taking into account the work of the various inter-governmental and non-governmental organizations and to report on the subject to a subsequent session of the Council; and (*c*) To develop close cooperation with cartographic services of interested Member Governments.

We have been much impressed with the fact that, in spite of the volume of informed opinion which our studies lead us to believe exists, both in economic and in political circles, as to the continuous necessity for maps at every stage of social and economic development, the world is still quite inadequately mapped. Due regard must certainly be paid to the mapping that has been achieved, but more remarkable to us is what has not yet been done. We have endeavored to elucidate the reasons for this rather astonishing situation, so that we might have a sound basis for our recommendations. It seems to us that they lie in a combination of circumstances, variously mixed in various parts of the world, namely:

(*a*) Lack of appreciation by national governments of the fundamental need for maps and of the wide nature of the public services rendered by them.

The non-existence of maps or the inadequacy of those available has brought on serious consequences in the execution of important developmental projects. This fact focuses attention upon an apparent but interesting paradox: the best mapped countries, which are also the most highly developed, today spend more for mapping than ever before. . . .

In an advancing civilization there is increasing and urgent need for more power, more food, and better communications.

* * * * * * * *

World-wide investigations and inquiries are carried out or stimulated by the United Nations. Important projects in various parts of the world are under consideration. The planning and launching of such projects, however, without the information provided by adequate maps, as has so often been the rule in the past and as is still quite usual, has invariably led, and always will lead, to waste of money far in excess of the whole cost of mapping, as well as to ultimate waste of time. The cost of mapping is a minute percentage of the total cost of projects taken in the aggregate, and the speed of modern technical methods of mapping, including aerial photography, now makes an orderly sequence of procedure entirely possible.

* * * * * * * *

The significance of surveying and mapping under-developed areas before any project can be undertaken, is worthy of particular mention.

The execution of such a survey will nowadays usually be based on the use of aerial photographs. The scale of these photographs may be influenced by the possibility of using them for other than map purposes, as has been indicated in (*a*) above. A little advance planning in determining the specifications of the aerial photography can pay handsome dividends in that the same photography can be at once the source of generalized information and the specific tool for topographic map construction. The presence of an experienced cartographer or photogrammetrist on the planning staff can assure this.

2. EXTRACTS FROM HOOVER COMMISSION REPORT ON ORGANIZATION OF THE EXECUTIVE BRANCH OF THE GOVERNMENT

More Adequate Basic Data Programs[1]

The committee is reluctant at this time to recommend increased appropriations for any Federal function within its province of study. It is foolhardy, however, for the Federal Government to undertake a development program running into billions of

[1] From Hoover Commission Task Force Report on Natural Resources.

dollars without spending enough money to obtain the basic hydrologic data essential to sound planning and construction. Yet that is precisely what is being done. Where error commonly runs high—25 percent—it is not difficult to see the possibility of enormous savings through the collection of more adequate basic data. The committee therefore recommends the immediate expansion of the programs of the basic data collecting agencies, so that the topographic mapping, ground-water studies, stream gaging programs, sedimentation studies, evapotranspiration studies, and run-off and erosion studies can keep pace with development programs.

Surveys and Records[1]

Adequate records and surveys are indispensable to efficient land-management programs. Without accurate basic and current data, land-management agencies are handicapped in the execution of their responsibilities. Yet the Federal Government has been laggard in the surveying and classification of large areas of public domain.

Need for Intensive Exploration[1]

A pressing need of the Nation is a more adequate supply of a long list of minerals to support and strengthen our industrial economy and to ensure our national securities. Hence encouragement of exploration should be the principal objective of the policies dealing with minerals and fuels on the public domain. Maintenance of the Nation's mineral reserves requires not only the discovery of concealed ore bodies in old districts, but the finding of ore bodies in entirely new regions where signs of ore evidence or conditions favorable for mineralization are not sufficient to have induced adequate exploration. To accomplish these ends, improved scientific knowledge of the occurrence of mineral deposits is essential and more refined techniques for testing areas for them must be devised.

Consolidation of Functions Relating to Water Control and Development[2]

We do not know the extent, limits, and duration of our most important natural resources measured by modern demands, and we are therefore equally ignorant of the need for development of existing resources or encouragement of substitutes and imports.

3. EXTRACTS FROM THE REPORT OF THE PRESIDENT'S WATER RESOURCES POLICY COMMISSION

The Need for Basic Information

Fundamental to all development and operation of water resources by public or private agencies is the availability in usable form of adequate information about water and related land resources, as well as about the region, the community, and the people to be served. Comprehensive planning in terms of river basins requires ample data on all aspects of regional and river basin development and of the hydrologic cycle.

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We simply do not have enough information for the best possible development of the varied resources of the country. We must obtain it at a much more rapid rate to meet enlarging requirements of an increasing population and of growing industries.

We need suitably scaled topographic maps, climatic maps, more knowledge of the geologic structure and mineral resources of the country, . . . and maps of kinds and extent of soils and other facts about characteristics of these soils. We must make faster progress in classifying land for capabilities, for the best and safest use, and for the vegetal resources.

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Only 25 percent of the area of the United States is covered by topographic maps considered acceptable by modern standards; only 10 percent of the area has been covered by modern geologic maps.

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[2] From Hoover Commission Task Force Report on Public Works.

4. EXTRACTS FROM THE REPORT OF THE PRESIDENT'S MATERIALS POLICY COMMISSION[3]

Aerial Photography

Aerial photography represents a significant tool which can be used widely, quickly, and relatively inexpensively in any programs of mineral discovery. The following examples are only a few of the uses thus far suggested:

To complete the topographic mapping of the United States and other world areas as quickly as possible by photogrammetric means. Topographic maps are needed in planning the systematic search for minerals, the preparation of geologic maps, and the efficient exploitation of all significant mineral discoveries. Photogrammetry, the science of making maps and extracting quantitative information from photography, offers the cheapest and fastest means yet devised for making topographic maps.

To prepare aerial photographic mosaics of potential minerals discovery areas as a basis for many types of annotations or transparent overlays bearing geochemical, geological, geophysical, geobotanical, and other earth science field data which may offer "convergence of evidence" as to place and type of mineral existence.

To extend, generalize, and disseminate the general principles of "photogeology." The geomorphic or land-form interpretations made through a three-dimensional study of aerial photos is valuable in arriving at structural conclusions that might not otherwise be determined. Photogeology itself is the most economical method of rapid geologic reconnaissance yet developed. By this technique outstanding structural anomalies can be located quickly and evaluation of these can proceed without the delay occasioned by detailed exploration. The interpretation of aerial photographs considers not only land form and obvious geologic units but also the effects caused by variations in reflecting power of soils and rocks of exactly similar colors, the habit and density of vegetation, drainage patterns, the distribution and pattern of cultivated lands, railroads, quarries, reservoirs, and other cultural features. The application of photogeology to exploration work should be considered as an aid rather than an end.

To precede every major mineral search with detailed aerial photographic study to locate critical or key zones and thereby save geological effort otherwise wasted in general reconnaissance.

To extend the use of the "convergence of evidence" principle by securing airborne magnetic or other instrumentation records simultaneously with black and white or colored photography over potentially fruitful mineralized areas. The most spectacular recent example of the successful application of this principle in a limited sense is the discovery in 1947 of what appears to be the world's greatest iron ore deposit, Cerro Bolivar, in Venezuela, by the U. S. Steel Corporation. Of outstanding importance to the Nation's mineral program is the fact that this huge deposit was discovered just in the nick of time. The U. S. Steel Corporation was just about to spend millions of dollars in a taconite (low-grade ore containing 25 to 35 percent iron) program which would have been much less fruitful.

5. QUOTATION ON RESOURCE SURVEYS FOR ECONOMIC DEVELOPMENT FROM PHOTOGRAPHIC SURVEY CORPORATION, LTD.

Let's Put First Things First

Having decided that it is vitally important to raise the standard of living in an underdeveloped land—just what procedure is to be followed?

Planner's views on that problem are widely divergent, and certainly the basic approach must be determined by the existing state of development. Areas likely to receive attention first because of their urgent needs are those where the population density is high in relation to food resources available, resulting in a precarious standard of living. Most such areas are located in Asia and, to a lesser extent, in Africa.

Frequently, there is a tendency to consider medical aid (establishment of hospitals, public health programmes, etc.) as the

[3] Volume IV, chapter 2, Improved Exploration for Minerals.

first requirement, with education as the second, and public works as the third. However, an alternative and much more logical approach is to consider the creation of a permanent employment potential first, so that health and education programmes may be self-perpetuating and coincident with a higher living standard.

The employment potential is dependent upon industry and agriculture, which stem from the country's natural resources—its soils, water, forests, minerals, fish, and game. Therefore, the first step to be taken is to determine the location and extent of the country's natural resources, considering at the same time detailed information on climate, existing communications, and population distribution. Then, and only then —when such an inventory has been taken —can an intelligent development plan be formulated. Resources offering the best potential for immediate development can be selected, and the problem of directing the establishment of industries is greatly simplified. Moreover, with complete inventory data available, fewer foreign technical experts are required to study overlapping problems and direct development work.

To sum up, it seems apparent that a programme of assistance to any under-developed area should be initiated by means of a complete and careful resources inventory.

(The above-mentioned resources inventories are undertaken with the assistance of *aerial photography* and recorded on *maps*.—ED.)

Part II. Specific Illustrative Examples of How Maps and Aerial Photographs Promote Efficiency and Save Money in Developmental Work

1. ROAD BUILDING

Quotation from Aero Service Corporation

Topographic facts were needed for the Pennsylvania Turnpike's eastern extension. The transit-and-line method estimate was $415,000 and 2½ years' time. Too slow —and too expensive.

Aero Service mapping planes flew the 140-mile route, taking 250 photographs to be translated into accurate contour maps by photogrammetry. First maps were delivered 45 days after photography—entire schedule completed in just 145 days. Net cost of the job was $83,000, one-fifth of the cost of ground surveys. (Authority, Gannett, Fleming, Corddry and Carpenter, design and location engineers for the Pennsylvania Turnpike Extension.)

Example cited by William Pryor, Bureau of Public Roads

The use of aerial photography is the only economical way of establishing a road location. In a certain instance in Latin America an engineer surveyed and designed a road location, using the old classic ground survey methods. Mr. Pryor made another location by the use of aerial photography not knowing of the original survey. Faced with conflicting recommendations for road locations, the superiors responsible for the decision as to the road location insisted on checking each route on the ground. In 24 kilometers it was found that the road location accomplished by aerial photography, as compared with the other, saved $400,000 in bridging cost and $300,000 in excavation costs.

Extracts from "What's a Map Worth?" by Leo J. Zuber, Metropolitan Planning Commission, Atlanta, Ga.[4]

The value of adequate maps was recently

[4] SURVEYING AND MAPPING, Jan.–Mar. 1952, pp. 14–18.

demonstrated in connection with the construction of a highway between two points 16 miles apart. Three location surveys were made at an approximate expenditure of $5,000 and the cost of the proposed highway was estimated from these surveys in the usual manner. Before the highway was constructed, the State geologists appealed to the governor to have a topographic map made of an area several miles wide along the route of the proposed highway. This map was compiled at a cost of $2,200 and from it a new route was selected. The cost of the highway constructed on the new route was $200,000 less than that estimated for the route selected before the topographic map was made.

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Likewise, Gen. Richard K. Hale, Director, Massachusetts State Highway Department, stated that the savings effected in the highway department alone could have paid the entire cost of the topographic surveys of Massachusetts.

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In one prewar year, $500,000,000 was spent for the construction of highways in the United States, according to Robert Stephenson of the Pennsylvania Topographic and Geologic Survey. Highway engineers estimate that $97,500,000 could have been saved in preliminary surveys and construction costs had topographic map coverage been adequate. In this case, the lack of topographic maps may be directly translated into a loss in tax money.

The chief engineer of one railroad saved $85,000 by changing the route of a rail line after examining a topographic map. This sum is a mere pittance when compared with the estimated $100,000,000 the railroads of the United States would have saved in preliminary surveys alone had topographic maps been available. No doubt the savings in construction costs would have reached an almost astronomic figure. Civil engineers have estimated that $28,000,000 per year in operating expenses could have been saved had the curves and grades been reduced. Topographic maps, had they been available, would have contributed greatly to effecting this tremendous annual saving. The estimated saving in operating cost for 1 year alone could pay for the topographic mapping of an area almost four times that of the Commonwealth of Pennsylvania.

Federal and State highway officials need contour maps in order to select the shortest and most level routes, plot bridge sites, and plan drainage. In 1938, U. S. highway construction cost $500,000,000. Highway engineers estimate that preliminary contour map coverage would have saved approximately $37,500,000 on surveys and cut construction costs $60,000,000.

Extract from "Value of Topographic Maps to the Massachusetts Department of Public Works" by E. C. Houdlette, Director, Survey Division, Mass. Dept. of Public Works[5]

Massachusetts had spent millions of dollars on the extension, improvement, and upkeep of its highway system before the publication of the new topographic maps. Much of this highway work has been done with the use of the old 1887 maps and I am confident that we have not, in all cases, selected the best routes. Lack of drainage data caused destruction of bridges, culverts, and sections of roads by heavy rains.

Extract from "Value of Topographic Map Series in Highway Engineering" by Warren Creamer, Director, Engineering and Construction, Connecticut Highway Department[6]

The National Topographic Map Series is the most basic essential for planning highways and bridges. Without these maps it would not be possible to properly conduct the required steps leading to the development of a well planned, correctly integrated, and well constructed highway system.

[5] SURVEYING AND MAPPING, Jan.–Mar. 1950, p. 20.
[6] *Ibid.*, p. 30.

2. WATER RESOURCES DEVELOPMENT

Extract from "Value of Topographic Maps to the Tennessee Valley Authority Program" by Reed A. Elliott, Chief, Project Planning, Tennessee Valley Authority[7]

It would be practically impossible to exaggerate the value of high-grade topographic maps for the preliminary planning of water control projects such as those of the TVA system. . . .

Conclusion: The foregoing discussion of some of the uses by TVA of topographic maps has been devoted largely to the engineering phases in the development of the various dam and reservoir projects. It is not, of course, a complete statement of engineering uses of maps in connection with such projects, and it necessarily neglects discussion of important related uses of topographic maps such as in malaria control problems, forest resource investigations, watershed protection planning, and general management of reservoir areas.

Reliable topographic and geologic information is basic and indispensable to the proper development of water resources and it is hoped that this paper will express our conviction that the value of having accurate, broad-coverage topographic maps available for all stages of engineering investigations cannot be over-emphasized.

Extracts from "Value of Topographic Maps to the Bureau of Reclamation" by John W. Dixon, Director, Branch of Project Planning, Bureau of Reclamation[8]

The Bureau of Reclamation, for example, would not choose to attempt to evaluate, or could not evaluate, the benefits from topographic maps. Without them, we wouldn't be in business. . . .

I trust that I have succeeded in pointing out that, while a good start has been made, as yet the Nation is inadequately supplied with topographic maps, river profiles, folios of geologic information, and many other types of basic data.

Extracts from "Value of Topographic Maps to Business" by R. W. Smith, Natural Resources Dept., U. S. Chamber of Commerce[9]

The Nation is now engaged in a greatly stepped-up program of river-basin development, principally in the Missouri River Basin and in the West. To show you the extent of this program for reclamation, flood-control, navigation, and power projects covering all of the river basins of the country, I quote from figures furnished Senator George W. Malone by the Chief of Engineers:

Federal River Basin Projects	*Estimated Cost*
Works already completed	$ 4,799,700,000
Projects under construction ..	4,593,000,000
Projects definitely planned ...	18,980,900,000
Projects planned for the long-range future	29,152,600,000
Total	$57,526,200,000

The Chamber of Commerce favors the development and construction of the water resources of the nation upon sound engineering and economic principles, including the expenditures of public funds upon carefully planned projects which will stand the test of economically sound investments. The Chamber believes that many of the projects whose total estimated cost is given above will not meet these tests because they are based on inadequate data—lack of topographic maps, rainfall, stream flow, and other data necessary to determine if they are sound both in respect to engineering and economic feasibility.

The Hoover Commision Task Force Reports on Natural Resources and on Public Works both point this out clearly, with examples. . . .

The country would be far better off if we were to accelerate the expenditure for

[7] *Ibid.*, pp. 5 and 9.
[8] *Ibid.*, pp. 11 and 13.
[9] *Ibid.*, pp. 33–34.

accurate topographic maps and other necessary engineering data rather than to rush into an accelerated but poorly planned program of river basin project construction. The benefits to be derived from river basin development are in direct proportion to the sound planning on which they are based. The first and foremost need for such sound planning is adequate topographic maps.

Extract from "What's a Map Worth?" by Leo J. Zuber, Metropolitan Planning Commission, Atlanta, Ga.[10]

In California existing topographic maps alone have saved the Division of Water Resources more than $2,250,000 according to Edward Hyatt, State Engineer.

Similarly, the Metropolitan Water District of Southern California could have saved $750,000 if inch-to-the-mile contour maps of the southeastern part of the State had been available, according to Julian Hinds, assistant chief engineer of the District.

A. H. Markwart, vice president, claims that "adequate maps of the Pit, Feather, Bear, and Stanislaus Rivers would have saved the Pacific Gas and Electric Company $200,000."

Likewise, good contour maps saved New York City hundreds of thousands of dollars when it ran aqueducts from the Catskill Mountains to increase its water supply.

Extract from a letter dated July 13, 1953, from T. T. Martin, Vice President, Gulf, Mobile and Ohio Railroad Co., Mobile, Ala.

For some years we have been studying the feasibility of tapping the Mobile River some twenty-five or thirty miles north of Mobile and leading fresh water through a series of sloughs down to the industrial area. It was relatively easy, with the topographic maps, to determine that a route for this water was available. To have made such determination without the use of these maps would have required a tremendous amount of investigation of marsh and swamp lands which would have been very difficult to traverse.

Extract from a letter dated July 16, 1953, from J. B. Converse, President, J. B. Converse and Co., Inc., Mobile, Ala.

Prior to the building of the Big Creek water supply system, the City of Mobile was in a critical situation, in our opinion, due to the fact that previous stream gauges that we had made indicated definitely that the water supply for this metropolitan area would be entirely inadequate should such a drouth as occurred in 1937 reoccur. Under the circumstances, if we had not had available for our use maps of the Hurley and Wilmer quadrangles, the building of the dam and the development of the new water supply might have been delayed for several years.

As you may know, Mobile has practically doubled its population within the last few years and your guess is as good as mine as to the damage that would have occurred had water for our local industry and homes been curtailed. In reviewing in my mind, the value realized from these maps in facilitating the elimination of this water hazard far exceeded $100,000.00.

This community has an assessed valuation now of about $170,000,000.00 and to have this water hazard hanging over their heads was in the nature of having a 170-million-dollar investment without any insurance.

Extract from September 17, 1953, letter from Maurice L. Miller, Consulting Engineer, Louisville, Ky., to Phil M. Miles of Kentucky State Government

I wish to advise as convincingly as I know how that this work has been the means through which many thousands of dollars in capital investment has been saved by our clients as well as many months of time of reconnaissance work, thus expediting engineering studies and concluding reasonably accurately the feasibilities of water supplies and its overall potentiality.

[10] *Supra*, footnote 4.

For example, at Stanford, Ky., these maps were the means through which a reliable source of water supply was definitely determined within economical means of the city to acquire. These maps, together with climatological and geological data made available through the Weather Bureau, United States Geological Survey, and State Geological Departments, and the Soil Conservation agencies saved the city over $104,000.00 by comparison had they continued along other plans in the absence of these data and maps. These maps focalized the areas most feasible which otherwise would have been missed. Many other valuable details would have been missed except for these maps, at another saving of nearly $10,000.00 (in one instance).

To obtain all details as presented through the use of the maps would have required many months of field work with the result that Stanford would not have had water as soon as they expected with the resultant loss of revenue and the probability of loss of life and property through fire and disease in the absence of water as occurred in the fall of 1952. Likewise, the cost of engineering would have been more than doubled to arrive at even a portion of the data presented through the use of these maps.

3. FORESTRY

Quotation from Photographic Survey Corp., Ltd.

Although it has taken two generations to compile a forest inventory of the Canadian province of Ontario, 90 percent of the work has been completed in the last four years, using air photography and photogrammetry. Today it would be quite possible to equip and man an organization to do this entire forest survey (150,000 square miles or 375,000 square kilometers) in two years.

Geological mapping, soil surveys, and other phases of resources inventory have been similarly speeded up by modern techniques.

Extract from "Value of Topographic Maps in Forestry Work" by H. E. Seeley, Dominion Forest Service, Dept. of Mines and Resources, Canada[11]

The preparation of a national topographic series of map sheets by regular quadrangles in accordance with latitude and longitude, often constitutes most of the spadework in the production of special resources maps such as forestry maps. Not only do they provide a base on which to establish the network of forest type lines but also without further ado they are of prime importance to the forester as a guide to routes of travel and accessibility of timber. Another point is that the importance of contour lines in relation to the cutting and transportation of wood should not be overlooked.

In the case of Canada, the Dominion Forest Service has been instrumental in investigating the value of a series of published forestry map sheets. . . . The scheme anticipates the coverage of the country by published forestry maps in a manner hitherto reserved for topographic, geologic, and soil maps. In this plan, forest inventory maps are produced by photo-lithographic methods. . . . The maps are prepared by the aid of air photographs and provide general information as to the type, height, and density of each subdivision of the forest.

4. AGRICULTURE

Examples cited by E. A. Norton, Assistant Chief, Soil Conservation Service, U. S. Department of Agriculture

(*a*) The cost of running contours by photogrammetric methods for the planning of the watersheds in the "Watershed Protection Program," under the jurisdiction of the Soil Conservation Service, averages about $1.00 per acre. This cost includes the cost of new aerial photographs. In

[11] *Supra*, footnote 5, pp. 34–35.

comparison, the per acre cost of obtaining the necessary contours by field survey methods would average $8.00 to $14.00 per acre. Involved in this work for fiscal year 1954 is about 3 millon acres. No doubt this acreage will grow—double or treble in years to come.

(*b*) A 25 percent saving in man-hours has been made by using photogrammetric methods in the compilation of all maps completed by the Soil Conservation Service during the last 10-year period. In addition to this saving, work of better technical excellence was accomplished.

(*c*) The cost of contour mapping required to lay out detailed irrigation and drainage work on farms in soil conservation districts averaged $0.30 per acre by using photogrammetric methods. An average of 2¾ million acres of this kind of work has been done annually for the last several years. The average cost of obtaining a comparable contour map by field surveys has been about $10.00 and this does not take into account interruptions for bad weather and necessary travel time.

(*d*) Aerial photo mosaics used in preliminary planning for a group irrigation and drainage job saved 55 percent of the time of planetable survey or other type of field survey methods of map development.

5. GEOLOGY AND MINING

Extracts from "Promoting Stripping Efficiency by Aerial Mapping" by George L. Hess[12]

Fast, low-cost air surveys provide facts for:

Estimated coal acreage	Locating spoil dumps
Delineating crop lines	Plotting property lines
Plotting boreholes	Planning redevelopment
Computing overburden	Planning rail spurs
Timber inventory	Aiding geologic study

Photo reconnaissance at a few cents an acre—topographic maps at half the cost of ground surveys—these are the air-survey economies that put up-to-date mapping coverage within the strip-mining budget. These savings, however, are only part of the reason why more stripping engineers are planning for aerial mapping of their properties. The multiple uses for aerial maps and photos is the big factor. . . .

Unlike ground surveys, aerial mapping is flexible. The same set of aerial negatives will do three jobs. First, you get aerial photos for stereoscopic study. They can be assembled into a photo-mosaic—a good reconnaissance map. Then, with the areas of interest defined, a contour map can be compiled from this same aerial photographic base. Each of these products of the aerial survey can be used in money-saving ways.

The map's usefulness develops and grows within the mining company. A number of companies have found that after the maps are at hand scarcely a week passes that an office solution is not found for problems which before could be solved only by sending men into the field. The saving in time, plus the saving in the cost of the field parties, is substantial. The needed map facts are there—detailed, accurate, up-to-date, and readily at hand for management decisions. They speed the solution of many an operating problem, from rapid quantitative estimates of acreage and overburden to broad redevelopment planning.

"Value of the National Topographic Map Series to the Geologist" by R. C. Stephenson, Asst. State Geologist, Pennsylvania[13]

Speaking as a geologist, I represent a field of science which has long championed the preparation of more and better topographic maps. . . .

Topographic expressions of geologic phenomena are invaluable to the geologist in his interpretation of earth history, and the advantage of good topographic maps in geologic investigations, is, therefore, obvious.

Engineers, soil conservationists, hydrolo-

[12] *Coal Age*, October 1950.

[13] *Supra*, footnote 5, pp. 18–19.

gists, foresters, militarists, and others, who in their activities deal with features of the earth's surface, turn to the topographic map for physiographic data—for "terrain appreciation." We see then that a phase of geology, namely physiography, is a principal concern of topographic map users, whether or not they are aware of it.

The accuracy of a geologic map is determined largely by the type and quality of the base on which it is prepared. If a good topographic base is available, the geologist can record the geology accurately in three dimensions. On the contrary, the lack of topographic maps may destroy much of the value of serious geologic effort. To illustrate specifically, the second geological survey of Pennsylvania (1874–1887) produced voluminous reports on the geology and mineral resources of the State. Fundamentally, this work was excellent, but the practical value of the resulting geologic maps was seriously limited by inaccurate horizontal control and little or no vertical control.

Extract from "Value of Topographic Maps to the Oil Industry" by George H. Lacy, Chief Engineer, Gulf Oil Co., Houston, Tex.[14]

In the early days of the oil industry, the "wildcatter" was a very colorful figure, and his methods were haphazard as well as crude. For instance, his selection of a drill site was chosen by a flip of a coin, perhaps, or he would sail his hat out, and wherever it hit, he would drill. . . .

Although science has not taken all of the risk out of prospecting for oil, there are very few exploratory wells where the most scientific methods known are not used, and they call on the geologists, the geophysicists, and the paleontologists to furnish this knowledge in trying to find a spot where oil can be found. . . .

It is obvious from the above that accurate topographic mapping of the area in which they are working is invaluable to those scientists. In conducting this investigation by geophysicists, naturally, it is necessary for them to have not only contour maps, but ownership maps.

[14] *Supra*, footnote 5, p. 23.

Extract from August 31, 1953, letter from Chief Geologist, Kentucky-West Virginia Gas Co., Ashland, Ky., to Phil M. Miles, Kentucky State Government

As to the completion of new topographic mapping of the State, I can assure you, from my twenty-eight years of experience in the gas development of Eastern Kentucky, that I consider this work by far the most important contribution to exploration of oil, gas, coal, and other minerals ever made.

The first and most important factor [needed before beginning] any exploration and development is a good base map. . . .

It is my honest opinion that from the standpoint of oil, gas, coal, and all other mineral exploration and development, and for highway and agricultural use and for military value, the new topographic maps are one of the greatest contributions Kentucky has ever made to her people and others interested in our great Commonwealth.

Extracts from August 13, 1953, letter from W. D. Charner, District Geologist, Carter Oil Co., Bowling Green, Ky., to Phil M. Miles, Kentucky State Government

It has been my experience during many years of petroleum exploration, that the results of any exploration program are greatly influenced by the quality of the basic surface mapping. It can be truly said that the quality of geologic mapping is only as good as the quality of the base maps used. Detailed work is not possible without a detailed and accurate base map. . . .

I think that the availability of the new topographic map influences to a degree the planning of locations for new exploration work. That is, where there is a choice of areas to work, we would undoubtedly put our efforts into an area covered by accurate topographic maps where possible to do so. Other areas we might hesitate to enter

at all because of the poor quality of old mapping, or entire lack of adequate mapping.

Extract from August 26, 1953, letter from President, W. G. Duncan Coal Co., Greenville, Ky., to Phil M. Miles, Kentucky State Government

[Our records show] that the topographic mapping is being done for about $12,000 for a 7½-minute quadrangle.

It is necessary for us to have such maps in advance of stripping or mining under less than 100 feet of cover. We do some of this work by transit and stadia methods on a 100-feet-to-one-inch scale and this costs about $3.00 per acre or almost 10 times the cost that you mentioned.

We have spent thousands of dollars making such maps that could have been saved if the Federal maps had been available earlier.

(Editor's Note.—The following five extracts refer to special magnetic maps which in turn are made with the aid of topographic and geologic maps and aerial photography.)

Extracts from "Aeromagnetic Survey Helps Find New Pennsylvania Iron Orebody" by Homer Jensen, Chief, Magnetometer Section, Aero Service Corp.

The advent of the airborne magnetometer only a few years ago aroused high hopes that mineral exploration would be tremendously aided. These hopes have been realized, and here is but one example—the discovery of a new large blind iron orebody in eastern Pennsylvania. The 900,000-acre air survey leading to the discovery was made at a cost of less than 7 cents per acre. Details are released through courtesy of the progressive mining company which made the recent important discovery. . . .

The airborne magnetometer recently discovered an important new iron ore deposit in a blind area in eastern Pennsylvania. The air survey located a massive magnetite body overlooked in many past ground studies. The body is at a depth of 1,500 to 3,000 feet and no surface expression is apparent.

Abstract of "Aeromagnetic Survey of the Allard Lake District, Quebec" by Weston Bourret

During the summer of 1947 Kennco Explorations, Ltd., made an airborne magnetometer survey of a large anorthosite body in eastern Quebec known to contain deposits of ilmenite-hematite. The purpose of the investigation was to determine the regional limits of ilmenite-hematite mineralization and prospect for additional deposits. Over 4,500 linear miles of magnetometer traverse were flown at an elevation of approximately 500 feet above the ground. The general geologic setting and aeromagnetic results are discussed. The survey was not only successful, but was completed in a small fraction of the time that would have been required by ground-traversing methods.

Extracts from "Airborne Magnetic Survey in Maine Speeds Search for Mineral Deposits" by Patrick M. Hurley, Geology Department, Massachusetts Institute of Technology

The increased demand for asbestos prompted active prospecting of an occurrence south of Spencer Lake in Maine last year, which led to interest in a belt of ultramafic rocks in this region that had been reported in the literature but not mapped. During the exploration of this 1,200-square-mile area in northwestern Maine, the correlation of magnetic and geologic data obtained by the airborne magnetometer and field parties demonstrated the utility of aerial magnetics in such reconnaissance work. . . .

Flying of the Maine area was completed during the first two weeks in May. By the first week in June, the preliminary magnetic maps were delivered, in time for planning and field use. . . .

The use of the magnetic intensity maps permitted rapid reconnaissance of the 1,200-square-mile area. In three and one-half

months, a three-man field party was able to map in reconnaissance the entire area, feeling at the conclusion that nothing of economic significance had been missed. This speed and assurance was possible because of the magnetic intensity maps, which proved to be ideal for blocking out areas which could be eliminated from consideration with a few traverses, and for indicating areas where concentrated examination was needed.

Extract from "Aerial Surveying Speeds Mozambique Exploration"[15]

Aerial reconnaissance with the mapping camera and airborne magnetometer is speeding exploration work by the Mozambique Gulf Oil Co. of its 42,000-square-mile concession area in Portuguese East Africa. Preliminary aerial magnetic maps covering 7,000 linear miles of the survey have already been delivered.

Extract from "Magnetic Air Surveys Go Global to Help in Revealing Ore and Oil" by David D. Frank[16]

Why the Airborne Magnetometer?

James R. Balzley, Jr., airborne geophysicist for the U. S. Geological Survey, answers with an example: "A four-man crew made a survey of 3,170 square miles in the Adirondacks with flight lines usually a quarter-mile apart—a total of 11,300 miles of traverse. The cost of an equivalent ground survey with dip needles would be 17 times as great as the airborne and would have required 27 six-month field seasons with a four-man crew—about 80 times the time required for the airborne survey. In addition, the ground survey would have been considerably less detailed and less accurate.

"The airborne magnetometer," he declares, "will by no means replace the usual surface instruments, but will certainly serve to delineate areas that deserve intensive work."

(Editor's Note.—The following discussion of "published geological reports" includes geologic maps as a major element. The field work was generally done with the aid of some topographic mapping and aerial photography.)

"The Role of Published Geological Reports in Foreign Mineral Development" by Dr. W. D. Johnston, Chief, Foreign Minerals Branch, U. S. Geological Survey

The question "How does the publication of a geological report on a foreign mineral deposit help its development?" might well be answered by reviewing the experience of the U. S. Geological Survey's work in Brazil during the past decade, during which field examinations in cooperation with the Departmento Nacional da Procudao Mineral have led to the publication of several reports that have played an important part in mineral development in that country.

The manganese deposits of Morro do Urucum, Matto Grosso, were studied in 1941 and Bulletin 946-A, published in 1945, called attention to a reserve of 33 million tons of 45.6 percent manganese ore. This deposit was then reexamined by the U. S. Steel Co., and, in 1949, that company entered into an agreement with the Brazilian concessionaires to finance a new company for its development and export.

The manganese deposits of the Serra do Navio District, Amapa, were studied in 1948 and Bulletin 964-A, published in 1949, estimated a reserve of 7½ million tons of 50 percent manganese ore. Subsequently the Bethlehem Steel Co. joined the Brazilian concessionaires in forming a joint U. S.-Brazilian company and drilled the deposit, proving a minimum of 10 million tons of 50 percent manganese ore. Railroad and port surveys are not completed and production is expected in about 2 years. When the two deposits are in production, the Western Hemisphere will be self-sufficient in manganese ore.

The nickel deposits of Sao Jose do Tocantins were studied in 1942 and Bulletin 935-E, published in 1944, indicated a reserve of 300 million pounds of nickel. Concurrently with the survey field work, the American Smelting and Refining Co. op-

[15] *World Oil*, March 1949.
[16] *Wall Street Journal*, December 20, 1947.

tioned the deposit, but abandoned its option because of uncertainties in metallurgical treatment. Having the published record encouraged the Falconbridge Nickel Co. to option the property in 1951 and plans are now under discussion for its development. It appears likely that the Defense Materials Procurement Agency will finance some part of this development.

The barite deposits of Camand Bay, Bahia, were studied in 1946 and Bulletin 960-A, published in 1948, estimated a reserve of 700,000 tons of commercial barite at tidewater. A Brazilian company in which National Lead Co. participates has developed this property.

The magnesite deposits of Central Ceara were studied in 1946 and Bulletin 962-C, published in 1950, indicated a reserve of 2 million tons of commercial magnesite. The Harbison Walker Co., learning of the deposits through the published bulletin, made a field check and, in 1951, formed a Brazilian company to develop the deposits.

The mica deposits of Brazil were studied in the war period, 1942–45, and a number of reports designed to aid mining were published in Brazil. In 1950, Bulletin 964-C, summarizing knowledge of Brazilian mica occurrences, was published. This information is now available should a new mica purchase program become necessary.

Other studies of beryl, tantalite, tungsten, and quartz crystal have been published in technical journals and in the bulletin series of the D. N. P. M. in Brazil. This information on occurrences and reserves of these strategic minerals is available should an emergency arise.

The point to be made is that competent technical field studies, including precise mapping of mineral resources, when presented in published form so that copies are freely available to industry, is an effective stimulant to the development of these resources. By publishing the results, the technical agency making the study plays no favorites—the picture of ore reserves is presented for all interested parties to see and to consider means for their development. Such studies must be made and published by an agency in whose technical competency industry has complete confidence, and the findings must be presented in the restrained form expected in sound engineering practice.

6. CITY PLANNING

Extracts from "Cleveland Buys an Aerial Map" by G. Brooks Earnest, Professor, Engineering Surveying, Case Institute of Technology, Cleveland, Ohio

At slightly less than half of ground-survey cost, and one-fiftieth of ground-survey time, Cleveland is getting an aerial topographic map that already is paying dividends in reduced project planning costs. . . .

The recently organized Cleveland Regional Planning Commission will tackle problems relating to both sanitary and storm sewerage distribution, freeways, parking, traffic distribution, rapid transit location, zoning, and other related planning for which the aerial photos and the topographic mapping will be indispensable.

Extract from June 10, 1953, letter from Mobile (Alabama) Chamber of Commerce to U. S. Geological Survey

We would like to take this opportunity to thank both you and your department for this project, for these maps have been and will be of great value to our office and the many people using them in our area.

By use of the topographical map and aerial photographs we are able, in most cases, to make a very satisfactory preliminary survey of an area and also we use a great number of these maps in spotting available industrial sites for interested industry.

It will be most difficult for us to give definite amounts of time or money that are

saved by use of these maps but I am quite sure that if it were possible it would be of considerable quantity.

Extract from February 24, 1953, letter from Thomas M. Moore, Realtor, Mobile, Ala.

I am speaking for my office, and the principal type of realty we handle is industrial real estate. We have inquiries from a great many different cities for industrial locations and are always asked to furnish maps with our reply and have found the 7½-minute quadrangle maps invaluable. . . . We greatly prefer to use the white background map; these maps are a considerable time saver and the cost to the user is small compared to the value of the maps.

Quotation from Dr. E. G. Faludi, President of Town Planning Consultants, Toronto, Canada

Air survey is to former methods what the jet aircraft is to the horse and buggy. For landowners, developers, contractors, and municipalities, we can estimate very exactly —with the aid of air mapping—that the cost per foot frontage in a given development will be *X*—and not *Y*. This method provides economy in development. We use it because we're practical people—because of its economic and technical advantages, we can't afford not to use it.

7. STATE AND REGIONAL PLANNING

Extracts from "Importance of Topographic Maps of the Maryland Planning Commission" by I. A. Pasarew, Director, Maryland, Planning Commission[17]

The Commission is called upon frequently by local levels of government and other State agencies concerning problems of housing, zoning, transportation, public utilities, aviation, recreation, capital improvements, economic surveys, and regional planning. Very often it is necessary that a hurried or preliminary appraisal be made which involves the use of an adequate topographic map. The USGS quadrangle sheets as presently prepared serve this purpose excellently. . . .

I might divert . . . to point out that ever so frequently time is a very important consideration in some of this planning effort, to the extent that if a program or planning can be fully developed and costs prepared on some reasonable basis, it means the difference between an appropriation either this year or 2 years from now, and for the institutions that are badly in need of such improvements, that is quite some delay. And as I have pointed out, with the use of these topographic maps we can frequently save considerable time with great advantage. . . .

What I have said here today should certainly prove to you, if there is any need for proof, that maps are a vital tool in our planning for the physical, social and economic development of our respective States.

Extracts from "What's a Map Worth?" by Leo J. Zuber, Metropolitan Planning Commission, Atlanta, Ga.[18]

What is a map worth? Is it worth what it costs to make? The real value of a map cannot be gauged by what it costs but rather by the service it renders. In a very real sense, sometimes maps do not cost anything; they pay for themselves. . . .

There are many instances in which topographic maps make a difference, a big difference. One community gets a new industry, but another isn't even considered as a possible location. A right-of-way is chosen for a highway or railroad, and engineers know that they have chosen wisely, correctly, and in a minimum of time. "Lost land" is placed on tax books. Hitherto unrecognized natural resources become available. Any one of these services can more than offset the original cost of a topographic map. . . .

In 1942 the U. S. Army was looking for a midcontinental location for a $30,000,000

[17] *Supra*, footnote 5, pp. 14–17.

[18] *Supra*, footnote 4.

chemical warfare munitions plant. It had to be built on fairly level terrain, close to railroads and to a source of pure water. In addition, it had to be near enough to a populous area to obtain labor, but far enough away to provide safety.

. . . In some places, long-range surveys were begun, but the Denver, Colo., Chamber of Commerce merely laid out the four sheets of large-scale topographic maps which cover the city and its adjacent area. . . . When the Army Engineers received this material, there was no need to make a trip. They could see all they were looking for on a map laid out in Washington. This was industrial location with a "new look"; and, by the method of the old Chinese saying that "one picture is worth ten thousand words," they were sold. In a matter of hours, Denver had a $30,000,000 industry.

. . . Engineers have estimated that as much as 70 percent can be saved on preliminary surveys for the selection of industrial sites if topographic maps are available, not to mention the advantages of a properly chosen site once the industry is established.

Taxable Property.—It is known that the area of Kentucky is approximately 26,000,000 acres, but somewhere within this vast region about 1,200,000 acres are unaccounted for. The practice of writing deeds to cover so much area "more or less," or "from a stone's throw from the old oak tree" is responsible for this 5 percent discrepancy. . . .

Natural Resources.—In one northeastern State it has been estimated that an adequate mapping program could be established and maintained at a cost of only fifteen-thousandths of 1 percent of the value created by the mineral, forest, and agricultural industries each year. Such an expenditure is insignificant in comparison with the benefits which could be gained through such a program.

Extracts from "Aerial Photography for State and Local Planning" by Francis A. Pitkin, Exec. Director, State Planning Board, Harrisburg, Pa.

In general, it is difficult to think of any phase of governmental planning involving the use of large areas of land which cannot be greatly facilitated by the use of aerial photographs.

(Note: Mr. Pitkin then lists 34 uses of aerial photography by the Pennsylvania State Government.)

. . . I could cite just one example—the selection of a site for a TNT plant involving something over ten thousand acres—where the immediate availability of air photographs enabled us to select a site satisfactory to the Army officials and which involved an expenditure for land acquisition $600,000 less than the site originally selected by the Army. The saving involved in this project far exceeds the cost of our Statewide air photography.

You will note that the long list of uses which I have just given apply only to the use of these air photographs by agencies of the State government. An equally impressive list of uses by local governmental agencies could be given.

New Book and Maps for Uranium Prospectors

Uranium—Where It Is and How to Find It is the title of a new book by Paul Dean Proctor, Edmond P. Hyatt, and Kenneth C. Bullock.

In addition to such subjects as economic uranium minerals, types of uranium deposits, where to find uranium deposits, sources of information, field equipment, and Geiger counters, the book includes a series of maps showing the uranium-bearing rock units of the Colorado Plateau and other important areas.

Copies of the new book may be obtained from bookstores or the national distributor, Resources Engineering Company, 3757 Wilshire Blvd., Los Angeles, Calif. The price is $2.50. Copies are also available for study at various libararies throughout California, including the Division of Mines Library in the Ferry Building, San Francisco.

Raydist in Hydrography and Surveying

By CHARLES E. HASTINGS

PRESIDENT, RAYDIST NAVIGATION CORPORATION, HAMPTON, VA.

THE ART of electronic surveying has been developing very rapidly since the last war. Pulse- and radar-type techniques as exemplified by Shoran have already found much use and have been proven as accurate surveying tools. Continuous-wave, heterodyne, phase-comparison systems such as Raydist show promise of becoming even more valuable in the field of electronic surveying because of their simplicity, reliability, considerably higher accuracy, and their suitability for operation at ranges beyond line of sight.

Phase-comparison systems without the advantages of the heterodyne principle have been widely used throughout Europe for the past ten years. They have been used for precise distance and position measurement and also for general air and marine navigation. These continuous-wave systems are rapidly gaining acceptance throughout large areas of the world in preference to the pulse systems generally advocated in this country.

All electronic surveying systems have one obvious advantage over optical methods of surveying in that they can be operated regardless of weather or visibility conditions. Continuous-wave techniques have, in general, marked advantages over the pulse-type electronic systems in that they offer considerably higher accuracy and are suitable for operation beyond line of sight, whereas the pulse-type systems are seriously limited in this respect. Raydist, by the incorporation of the heterodyne principle, has not only the advantages common to all continuous-wave systems, but offers still higher accuracies with a minimum of frequency requirements.

Within the past few years, Raydist has been able to prove these advantages in field operations and to establish its value as a surveying tool. First-order surveying accuracies have been obtained under some of the most unusual and exacting field conditions. Raydist has been used on a 24-hour basis, day in and day out, by both Governmental and commercial users. Propagation paths have included sea water, fresh water, dense tropical growth, rugged mountainous regions, and virtually all combinations thereof. Ranges in excess of 250 miles have been achieved without the necesity for high-altitude flights. Systems have operated in excess of 100 miles at night, have operated well beyond line of sight, and throughout all types of weather including severe thunderstorms. Increased ranges are of course practical with increased power, higher antennas, and lower frequencies.

These results are not limited to our own operations. As will be discussed later, the Bureau of Standards recently used Raydist techniques (reference 1, at end of this article) to measure a distance of 1,500 meters (less than 1 mile) and reported a probable error of better than 1 part in 90,000. J. Th. Verstelle of the Dutch Navy also reported recently that by the use of phase measurements in Europe they were able to measure lines of 162 kilometers, 157 kilometers, and 171 kilometers with absolute accuracies of 1 part in 54,000, 1 part in 63,000, and 1 part in 90,000 respectively, (reference 2). Mr. Verstelle's opinions regarding the accuracies obtainable with phase-comparison, continuous-wave systems are essentially the same as those expressed herein; namely, that early inabilities to obtain high accuracies for overland distance measurements resulted from insufficient experience with early equipment and lack of knowledge of propagation considerations and data evaluation, rather than from any inadequacies of the basic phase-comparison techniques.

Before discussing the individual jobs in which we have successfully used Raydist during the past few years, let us first con-

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sider just what Raydist basically is and how it is used in the various types of applications.

FUNDAMENTAL PRINCIPLES OF RAYDIST

I shall make no attempt here to discuss at length the technical details of Raydist systems. Much information of this type has already been published (references 3, 4, 5, and 6) and is available from the writer for those desiring more technical information.

Let me just say, simply, that Raydist is a primary method of determining distances or differences in distance in terms of phase shift. Basically, continuous-wave transmitters emit continuous radio signals which differ from each other by audio frequencies. These heterodyne audio frequencies are received at two or more points. By comparing the phase of the signal as received at the various points, accurate distance determinations can be made. Determination of precise distance to several points allows determination of position, either in a plane or three-dimensionally in space.

System configurations and equipment arrangement vary depending upon the application and the type of data presentation desired. Some Raydist systems are hyperbolic in nature in that the data are determined in terms of hyperbolic lines of position. Other Raydist systems are not hyperbolic and data are presented directly in terms of range. Some systems are "saturable," meaning that only a limited number of users may obtain data from a given system simultaneously. Other systems such as those now in use in the Gulf of Mexico by the oil industry are "non-saturable" and supply position data to any number of users simultaneously.

Not only do the systems vary, but the locations of the Raydist components often vary within the same type of system. In the hyperbolic system, for example, the Raydist components have been arranged to determine the position of a boat or aircraft and to record this position either in the moving object or at some fixed remote ground station. Systems have been supplied with duplicate indicating equipment so that the position data recorded at the ground station are also simultaneously indicated in the moving object. Tracking applications naturally require an arrangement with the data recorded at a ground station while navigation requires position data in the moving vessel. Location of the equipment depends primarily upon the end results desired by the user.

NEWEST RAYDIST SYSTEM—TYPE ER

The newest Raydist system, Type ER Raydist, is probably the most suitable for hydrography and surveying applications, and is therefore the only system I shall discuss in detail at this time. For more complete details see reference 3.

The type ER Raydist is not hyperbolic but furnishes the user position data directly in terms of range from two known points. No hyperbolic computations or overlays are required, and the plotting of points may be performed on maps of any scale.

The system consists of two shore relay stations and the shipborne equipment as shown in figure 1. All of the equipment is light, portable, and requires very little installation time. The shore stations are set up at any convenient locations along the coastline. The ship-borne equipment normally consists of a continuous-wave transmitter, the Raydist Master Station equipment, and the desired indicating and recording equipment. However, the Master Station equipment may be located at a fixed shore point if it is desired to record the position at a shore station rather than use the data for navigation purposes.

As a surveying tool, Type ER Raydist allows distances to be determined quickly and easily without hyperbolic calculations or overlays, offers increased precision over greater areas because it is not subject to the severe geometric dilution of precision of hyperbolic systems at the greater ranges, and offers real advantages in savings of time, money, and effort.

RANGE AND ACCURACY

Similar to the comparison between the equipment and techniques necessary for

first-order triangulation nets and ordinary surveying, simple light-weight Raydist equipment is sufficient for general surveying work and heavier equipment and more care are required for long ranges and highest possible accuracies.

From the fundamental equations of the mathematics of Raydist (reference 4) it can be shown that the accuracy of Raydist measurements depends essentially upon two factors; the stability of the frequency transmitted and the velocity of propagation of radio waves. A third factor, the accuracy of the actual phase measurement, would only become important at very short ranges or at extremely low frequencies. Frequency stability can easily be controlled to a few parts per million, leaving the correct value of the velocity of propagation of radio waves as the only important factor in question.

The uncertainty of the exact correct value of the velocity of propagation and the determination of the relative effects of such constants as terrain, humidity, etc., on this value have probably been the biggest difficulties encountered in quickly adapting these phase-comparison techniques to first-order accuracies.

As early as 1948 the Bureau of Standards recognized the value of applying Raydist techniques to high-precision methods of studying these constants and at that time they awarded us a contract for work in the field of velocity of propagation measurements. Since then the Bureau has done considerable additional work along these lines and has recently published some of the results of the studies (reference 1).

The Bureau, in measurements made over flat arid country in the West, using Raydist techniques, obtained data which, when evaluated in terms of distance by using the velocity of propagation generally accepted by the electronics industry, checked to within 1 part in 143,000. Using the velocity of propagation obtained by the new molecular method, the values checked to 1 part in

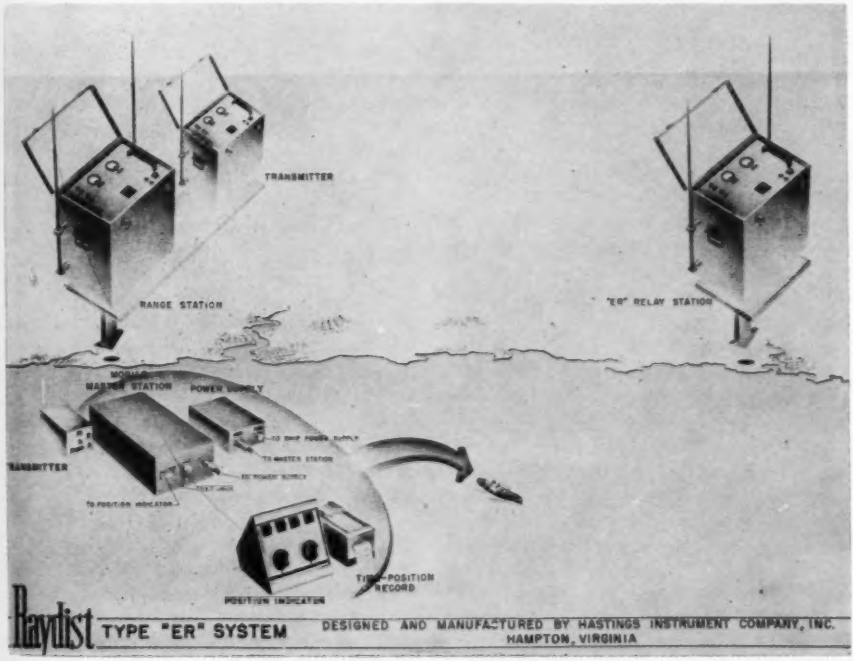
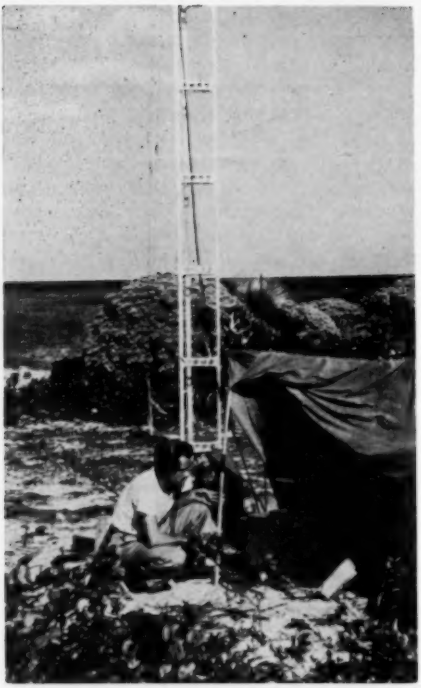


FIGURE 1.—Type ER Raydist.



A TYPICAL RAYDIST RELAY STATION AND ANTENNA BASE. ALL EQUIPMENT IS LIGHT AND PORTABLE, AND THE COMPLETE SITE CAN BE ESTABLISHED WITHIN SEVERAL HOURS.

97,000. It is noteworthy that to have obtained these accuracies over the short baselines used, the distance measurements with Raydist techniques would have had to be accurate to less than 2 centimeters or a little more than one-half an inch.

These results, as the Bureau of Standards points out, were obtained under carefully controlled field conditions. So, of course, are all first-order accuracies, whether optical or electronic. It appears certain, however, that as our knowledge of propagation factors increases and our accumulation and analysis of empirical data increases, accuracies much higher than those required for first-order surveying are assured.

Ranges in excess of 250 miles have been obtained with light-weight equipment using medium-range frequencies. At low frequencies with greater power and larger antennas, ranges of 3,000 miles seem entirely practical. The stability of atmospheric propagation considerations has now established that first-order accuracies could be obtained even at these ranges, assuming the selection of appropriate operating frequencies. To achieve first-order accuracies at ranges of the order of 2,000 miles the frequencies would certainly have to be below 200 kilocycles. At ranges of less than 1 mile, to obtain corresponding accuracies, frequencies above 100 megacycles and directive antennas similar to those used by the Bureau of Standards would be required.

Some of the best data released to date relative to accuracies obtained with Raydist when tracking three-dimensionally the position of an aircraft in space were obtained by the Patrick Air Force Base Missile Test Center (reference 7). An evaluation of the accuracy of the Raydist data was made by determining the position of the aircraft simultaneously with Raydist and with optical measurements throughout the range of the optical instruments. Raydist, however, tracked the aircraft long before it got within range of the optical instruments and long afterwards. The Raydist data were considerably smoother and less erratic than the phototheodolite data, and the results are rather conclusive that Raydist was well within the checking accuracy of the theodolite optical data.

LANE COUNTS AND AMBIGUITIES

The very high accuracies obtainable with Raydist are in part due to the fact that the accuracy with which the shift in phase is measured does not have to be the equivalent of the accuracy to which the distance is being measured. In other words, the phase-shift measurement is the equivalent of a vernier reading which is added to or subtracted from the total number of lane-count readings to obtain the distance. Thus, it is necessary to know both the number of whole counts or lanes and also the phase-shift readings for the exact position in the given lane.

There has been criticism of phase-comparison systems based on the fact that it is

necessary to resolve ambiguities regarding the lane count to obtain the correct measurement. Resolving the ambiguities by actually counting the lanes might result in an error either because of an error in the counting process itself or because of an unreadible section of the record due to the failure of equipment or excessive interference at some particular time at or near maximum range.

A relatively simple method has now been proven pratical for long lines where counting of lanes to determine whole count would prove burdensome or under conditions where questions might arise as to the correct number of whole counts. By making measurements on several frequencies and calculating the number of whole counts or lanes, it is not necessary to go through the tedious job of counting them on the records. However, automatic counters have been developed and proven entirely reliable if satisfactory antenna arrangements can be made on the aircraft or vessel and sufficient power is available for the range over which the system is being operated.

TYPES OF RAYDIST APPLICATIONS

Although it is necessary to take special precautions and use utmost care in order to obtain first-order accuracies, there are nevertheless many types of surveying work

A COMPLETE RAYDIST MASTER STATION INSTALLATION WITH LARGE AUTOMATIC PLOTTING BOARD FOR TRACKING OF AIRCRAFT ON A TWO-DIMENSIONAL BASIS. THIS PARTICULAR UNIT WAS INSTALLED AT WRIGHT-PATTERSON AIR FORCE BASE.

which do not require the ultimate in precision but in which such factors as portability, operation beyond line of sight, operation in all types of weather, and general practicability of equipment are the important considerations.

One such type of application is that of hydrographic surveying. The precision of our hyperbolic systems has always been excellent and the Norfolk District of the Corps of Engineers has been using such a system for dredging channels in the mouth of Chesapeake Bay for some years and has found it highly satisfactory and very time-saving (reference 8). However, this is a continuing operation over the same area and it has therefore been practical to make up hyperbolic overlays with a scale of 1 inch equals 200 feet in the critical channel areas.

Very satisfactory Raydist hydrographic surveying operations have also been obtained over the past few years by the Hydrographic Office of the Portuguese Navy off the Bank of Sofala in Portuguese East Africa, Mozambique, and off the Colony of Guine in West Africa (references 9 and 10 respectively).

Raydist has also been in continuous use for the past several years for precise surveying and positioning in the Gulf of Mexico along the coasts of Louisiana and Texas for oil exploration and well-location operations for the oil industry (reference 11).[1]

Most hydrographic operations, however, are continuously moving along the shoreline or river and hyperbolic overlays are therefore expensive and cumbersome. The Coast and Geodetic Survey has felt that hyperbolic systems for their applications were impractical and not until we had satisfactorily developed our Raydist ER System which allowed the distances to be determined directly in terms of range did they feel it was worth their while to evaluate Raydist systems.

Late in the summer of 1954, at Sarasota, Fla., the Coast and Geodetic Survey used the Type ER Raydist System in some evaluation tests in the Gulf of Mexico. This area was selected because it was the critical location in relation to heavy thunderstorm conditions and radio interference. It was believed that if the system proved practical under these conditions, it would have passed the extreme tests. We were particularly pleased with the unpublished reports (reference 12) which indicate that, with small equipment and antennas radiating energies from small temporary installations on the beach with power of less than 20 watts, practical operation was obtained as far out as 20 miles in the Gulf, that for three weeks it was possible to operate on a 24-hour basis, day after day, without any failures of the Raydist equipment, and that, in spite of severe thunderstorms, completely satisfactory operations were obtained.

It was found that the differences between calculated values and Raydist indications were never greater than 5 meters and repeatability of the Raydist system from day to day was generally better than one-half of this amount. There was a considerable amount of data in which the repeatability was better than 1 meter. Due to antenna structures in close proximity to the metal objects on the vessel and the fact that the antennas were not at a single point on the vessel, the apparent position of the boat in the system varied as much as 5 meters. From a study of the data it seems that, if a different effective center of the boat had been determined, the position error of the boat would have been less.

A system has recently been completed for the Brazilian Hydrographic Office, in which we built equipment essentially the same as that used by the Coast and Geodetic Survey, but also supplied 100-watt amplifier units so that, when the 10-watt transmitters were insufficient for the requirements, they could be used in conjunction with the amplifiers to supply 100 watts of transmitted power. This enables the user to have the advantage of the lighter 10-watt equipment for most applications, but the ability to use 100 watts of power when necessary.

Considerable Raydist experimentation has also been done with helicopters. It has

[1] *See also* "Electronic Surveying in Offshore Areas," by G. A. Roussel, SURVEYING AND MAPPING, Jan.–Mar. 1955.

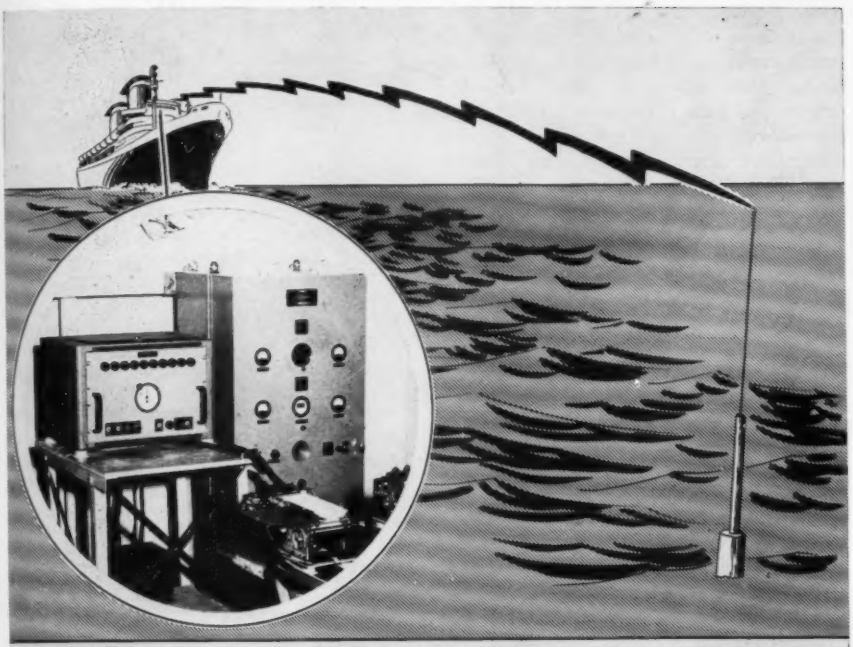

NEW RAYDIST SYSTEM USED FOR "UNITED STATES" SPEED TRIALS
A SMALL BUOY CONTAINING "RAYDIST" EQUIPMENT IS PLACED IN THE WATER. AN INDICATOR AND RECORDER IS INSTALLED ABOARD SHIP. THE SHIP MAY MOVE IN ANY DIRECTION FROM THE BUOY AND A MEASUREMENT OF A DISTANCE AND SPEED CAN BE MADE AS ACCURATE AS 1 PART IN 5,000.

FIGURE 2.—Inset shows Raydist equipment aboard the *S. S. United States.*

been found practical to indicate the position of a helicopter in the cockpit, or, with only a small transmitter in the helicopter, position of the craft can be determined on the ground.

A little over a year ago we also were able to take Raydist data and feed it directly into the automatic pilot of a helicopter so as to give automatic two-dimensional control of the helicopter. The system was set up at Patrick Henry Airport near Hampton, Va., so that left-and-right and fore-and-aft signals were supplied to stablize the helicopter and maintain it on a fixed vertical axis in space. During this experimental work the greatest problem was in the stability of the helicopter combined with the autopilot system, but with Raydist controlling the autopilot, it was found possible to control the position of the helicopter to within a 5-foot circle as the pilot ascended vertically to 1,100 feet, the highest altitude tested. This precision could be attained so long as the stability of the helicopter due to winds or other factors did not adversely affect the system.

An interesting application of Raydist to speed trials of ships is indicated in figure 2.

SUMMARY

Raydist has proven itself capable of first-order surveying accuracies. Raydist offers, in addition, advantages of simplicity, reliability, minimum frequency requirements, and operation beyond line of sight.

Raydist has been successfully used for hy-

drographic mapping and charting, surveying of large over-water areas and difficult terrain, tracking of high-speed missiles and aircraft, and navigation and positioning services in connection with hydrographic exploration and seismic operations. Raydist systems are equally applicable to all other types of applications where precise position or distance determination is required.

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Graphic Time Table of the Heavens

THE Maryland Academy of Sciences publishes annually a condensed and simple almanac in graphic form. This Graphic Time Table gives the rising and setting times of the Sun, Moon, and brighter planets; the eclipses; the occultations of bright objects by the Moon; and other useful astronomical information.

Computed for 40° North Latitude and 90° West Longitude (6 hours west of Greenwich), it is, therefore, exactly correct for only this point on the Earth. The table can be used to advantage anywhere in the United States, provided the user makes correction for the distance he may be east or west of his own time meridian.

A table shows the plus or minus time corrections for the major United States cities.

The standard chart measures 17 by 11 inches; a large (40- by 27-inch) wall chart contains additional information. Complete instructions for use of the Time Table are given on the back of the chart, with a summary of the changing events in the sky for the year.

Copies of the Time Table may be obtained from the Maryland Academy of Sciences, Enoch Pratt Library Building, 400 Cathedral St., Baltimore 1, Md., at 25 cents each. On orders of 20 or more, the price is 15 cents each. The price for the large wall chart is $1.00.

The Electronic Distance Meter for Precision Traverse Surveying

By ERWIN GIGAS

INSTITUTE FUR ANGEWANDTE GEODASIE, FRANKFURT a. M., GERMANY

THE IDEA of modulating light waves of about 0.6 μ wave length is not new. The unmodulated light wave is too small a unit for measuring large distances. It is used only as a carrier wave and a much larger modulated wave of more than 10 meters is impressed upon the light wave. If, for instance, a frequency of 8.3 megacycles is used, we get a modulated wave of about 36 meters. Since light waves reveal themselves in a manner similar to wave crests and troughs, complete darkness (nodes) will be encountered every 18 meters and in the same way, but displaced by 9 meters, utmost brightness every 18 meters. Thus, a modulated wave corresponds to a scale with divisions 18 meters apart.

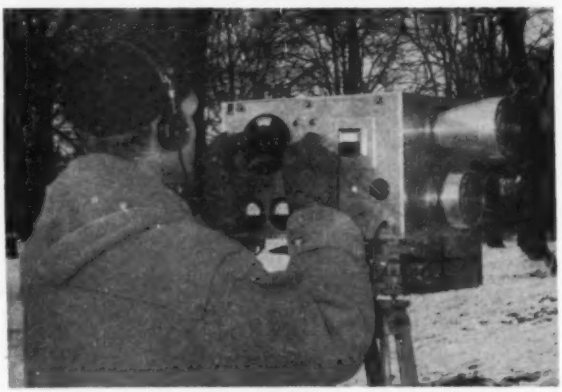
If this method is used to measure distances, measurements of light intensity have to be made at both ends of the line at exactly the same moment. If, at the starting and end points, the light intensities are found to be equal, the distance is a whole multiple of 18 meters. If the intensity differs at the end points, one of the end points would have to be moved forward or backward by not more than 9 meters in order to obtain equal intensity at both end points.

Since it is very complicated to compare the intensity of light at two distant points at the same time, the light at the far end of the line to be measured is reflected by a mirror and the intensities are compared at the starting point. This means that twice the distance is measured.

BASIC PRINCIPLES OF THE INSTRUMENT

The practical application of this method involves two basic problems:

1. The modulation of light waves.
2. Intensity comparison of the emitted and reflected light.



Field operation of the EDM, laboratory model.

The first-mentioned task was solved about 20 years ago, when Mittelstädt and later Hüttel in Leipzig modulated light by high frequency in order to determine light velocity. They applied a Kerr cell for this purpose.

A Kerr cell is a small glass vessel (fig. 1), filled with pure nitrobenzene ($C_6 H_5 NO_2$). Two electrodes at very close range dip into the liquid and a high-frequency voltage is applied. This voltage between the elec-

Presented at the Fifteenth Annual Meeting, American Congress on Surveying and Mapping, Washington, D. C., March 9–11, 1955. In the absence of Dr. Gigas, the paper was read by G. Stubbe of the Askania-Werke, AG, Berlin-Freidenau, Germany.

See also "Surveying With the Velocity of Light," by Milton E. Compton, Jr., SURVEYING AND MAPPING, July–September 1954.

trodes produces a rotation of the plane of polarization of the polarized light.

The light from the light source directed by an optical system, which is not shown, strikes a Nicol prism, which polarizes the light beam. It then passes through the Kerr cell to a second Nicol rotated through 90°, which blacks out the light beam. By applying an a.c. voltage, the plane of polarization is rotated and the effect of the second Nicol, depending on the voltage, is more of less cancelled. Depending on the frequency of the a.c. voltage, a modulated light wave is produced. The characteristics of such a Kerr cell are also shown in figure 1. The voltage, ranging to 2,000 volts, is represented as abscissa and the light intensity in scale divisions as ordinate.

After passing through the second Nicol, a modulated wave will be transmitted over the distance to be measured.

Now, the second question has to be solved —namely, how to compare the intensities of the emitted outgoing and reflected incoming light. As has been stated at the beginning, the measurement has to be made at the starting point. At the far end, a plane mirror reflects the light beam. The incoming light will be transformed in the photocell into an electrical current which, amplified in the photo-multiplier a million times, can be used for the measurement of the phase difference. There are different methods for determining the phase position with an indicating instrument. A well known solution is shown in figure 2.

The output voltage of the photomultiplier controls two tubes in parallel which are influenced in push-pull by the voltage of the Kerr cell. It can easily be shown that the galvanometer at phase differences of 90° and 270° will indicate zero. To eliminate zero errors, one voltage can be reversed by a switch.

DESIGN OF THE INSTRUMENT

The intention of the Institute for Applied Geodesy in Frankfurt was to design a lightweight portable instrument which would not require any approximation of the distance and which would be so easy to operate that it could be used like a theodolite on an ordinary tripod. Lengths of 200 up to 2,000 meters of precise traverse could be

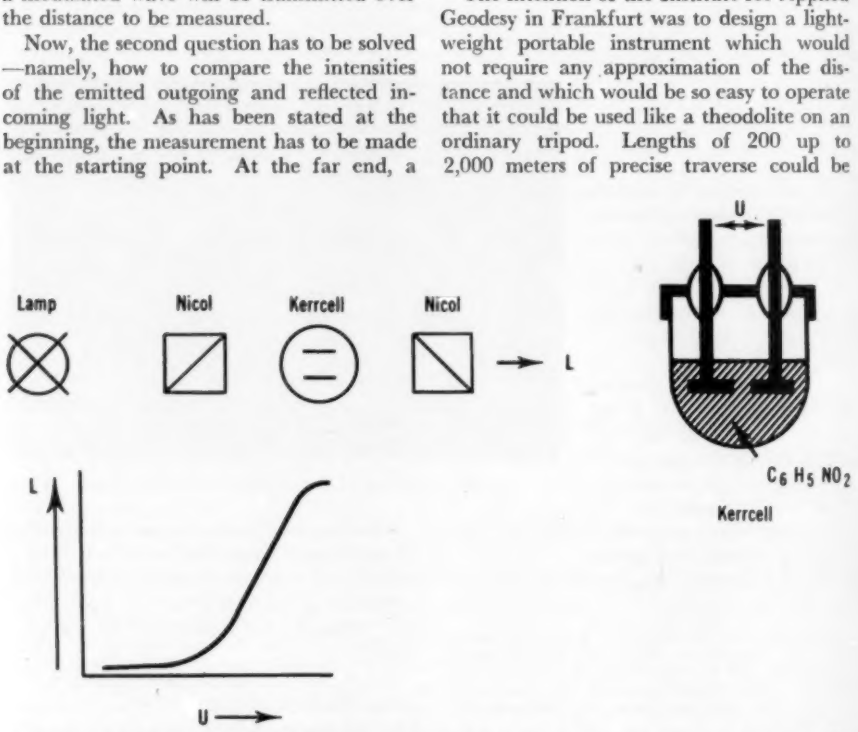


FIGURE 1.—Modulation of light waves by use of the Nicol prism and Kerr cell. In the graph, U = voltage and L = light intensity.

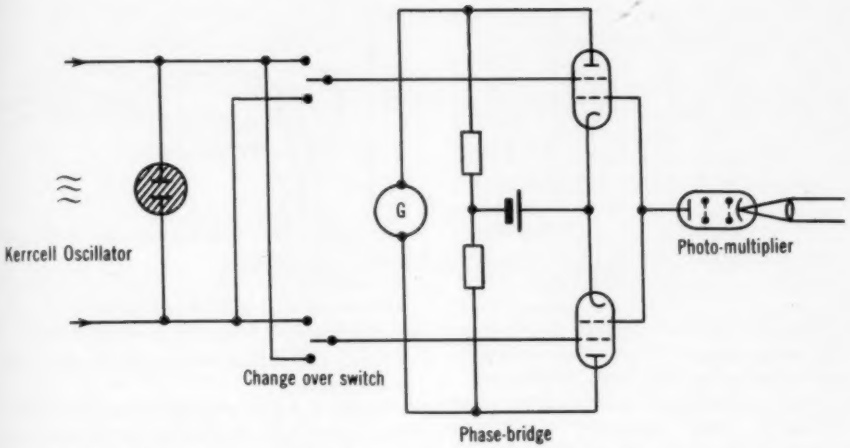


FIGURE 2.—Setup for measuring the phase difference between emitted and reflected light.

measured, thus replacing third-order triangulation. In this way, control points would not be located on inaccessible hills but rather on highways, waterways, or railroad lines—in other words, in places where the fixed points are required for later detailed surveys. The design of this instrument, which in its essential parts has been developed by my associate, Mr. Nottarp, is explained in detail in the following paragraphs.

Figure 3 shows the path of the rays within the instrument. The light produced by a light source of high luminosity passes through a condenser and a diaphragm, is polarized in the first Nicol, and is led into the Kerr cell by means of an intermediate objective in which the plane of polarization is rotated by and in phase with the modulated radio frequency voltage. By a telescopic lens system and the mirror at the far end of the line, the light is transmitted through the full distance, forward and back, to the second Nicol and into the photomultiplier. By placing the second Nicol in the path of rays at the receiver side, background light is largely suppressed, thus making possible measurements in daylight.

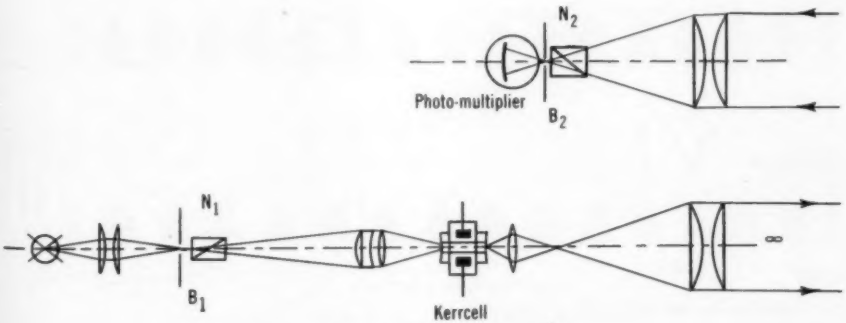


FIGURE 3.—Path of rays in the EDM.

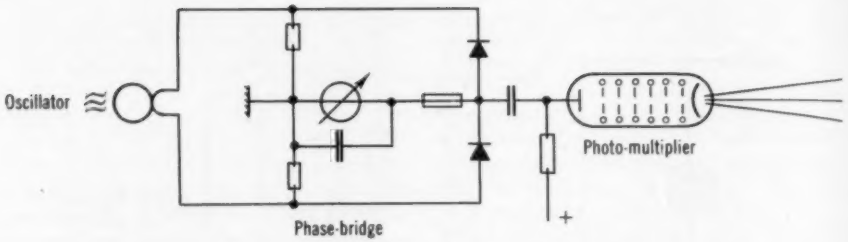


FIGURE 4.—Phase-discriminator arrangement.

Figure 4 shows the phase discriminator. The output current of the photo-multiplier, corresponding to the light modulation, is fed into one neutral branch of the phase-measuring bridge and the comparative current of the Kerr cell oscillator into the other branch. In this case as well, the galvanometer will only indicate zero at a definite phase relation of both currents.

Figure 5 shows different possibilities for fixing the bias point on the Kerr cell characteristics. In the first case, on the left side of the diagram, only the linear part of the curve is used; modulated high-frequency voltage and emitted light pulses are uniform. In the second case (center of the diagram) the bias point is at the knee of the curve. Only half waves are transmitted; the modulation depth is doubled compared to the first case. In the third case (right side of the diagram) the bias point is used at the start of the curve and both half waves are transmitted in push-pull, the modulation depth having also been doubled. This latter method of modulation contributes largely to a clear-cut zero transit of the phase-indicating galvanometer.

OPERATION OF THE INSTRUMENT

Next, the actual measuring of distances is explained.

Figure 6 shows a diagram of sinusoidally modulated light corresponding to a modulating wave length, λ_R. The pulses will strike the plane mirror (which is not shown) in the middle of the row and the mirror will reflect the light. These reflected pulses are drawn in the same direction as the outgoing beam, the upper row thus representing double the distance ($2\,E$). This distance generally will not represent a whole multiple of the wave length λ_R, so that, when determining the phase position of the transmitted and reflected wave train, a phase difference is observed which corresponds to the distance R. Now, the wave length λ_R is extended somewhat to λ_0, so that the remaining distance R disappears and phase coincidence is attained. This is shown in the second row of figure 6 where

$$2\,E = x \times \lambda_0$$

x being an integer.

If λ is extended further, a phase difference will again be present until λ becomes

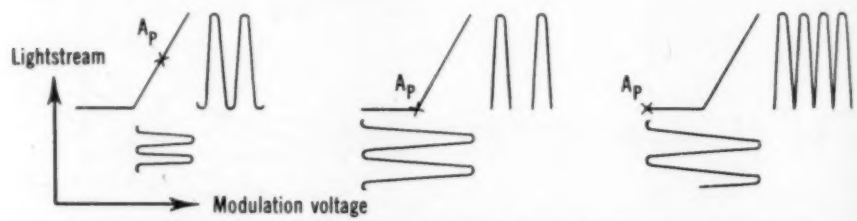


FIGURE 5.—Different possibilities for fixing the bias point on the Kerr cell characteristics.

equal to value λ_1, so that

$$2E = (x - 1) \times \lambda_1.$$

The range of frequency variation of the instrument can be altered still further, obtaining in this manner

$$2E = (x - 2) \times \lambda_2$$

$$\cdots\cdots\cdots\cdots\cdots$$

$$2E = (x - n) \times \lambda_n$$

Two equations suffice to eliminate x and to determine E. The other equations permit several additional determinations of E.

For technical reasons it was considered advantageous to specify a required accuracy of $1 : 10^5$ at a distance of 2,000 meters not only for the modulated Kerr cell oscillator, but also by comparison with a quartz standard. The frequency of the Kerr cell oscillator (8.0 to 8.9 megacycles) is determined by comparison with the 4th harmonic of the measuring oscillator (2.0 to 2.2 megacycles). This can be done by means of a headphone which indicates by a hissing sound when the Kerr cell oscillator vibrates exactly at the 4th harmonic of the measuring oscillator. Its frequency is then accurately determined to $\pm 3 \times 10^{-6}$. The measuring oscillator in its turn is standardized in the same manner by means of the 40th up to 44th harmonics of a built-in temperature-compensated quartz oscillator (50 kilocycles) to within $\pm 1 \times 10^{-7}$, making possible a precise scale calibration at 5 points of the scale. The long range constancy of the quartz oscillator can again be controlled by measuring a calibrated base the distance of which is sufficiently well known.

Figure 7 shows the instrument in its rather bulky laboratory construction; the lower objective is used for the outgoing light beam, the upper one for the incoming light beam after it has travelled back and forth through the distance E. The black knob in the center controls the frequency of the Kerr cell oscillator. The galvanometer on the right side above permits the observation of the phase position. The knob on the right side below is used for switching the instrument from calibration or measuring to "off." The scale of the measuring oscillator can be seen on the left side above. Both measuring instruments on the left side below show the operational status of the instrument. In addition, at the left side,

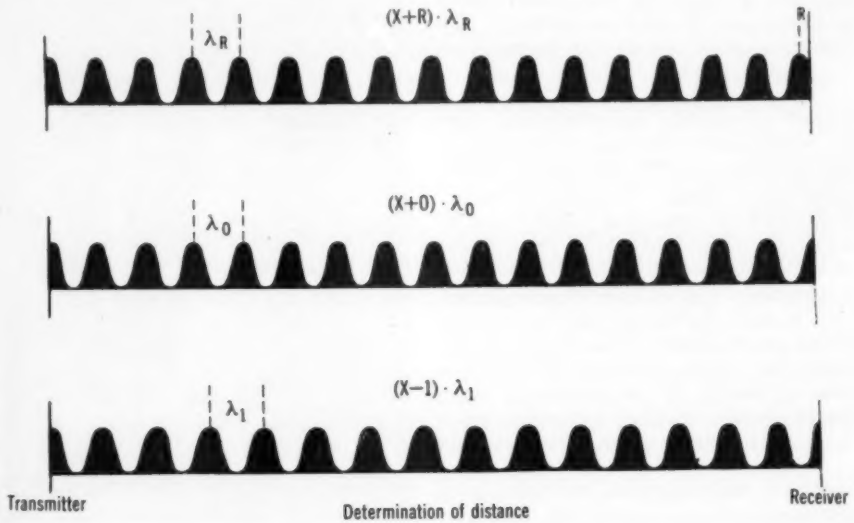


FIGURE 6.—Measurement of distance with the EDM.

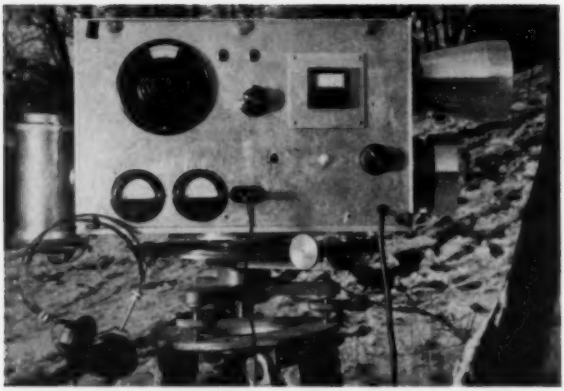


FIGURE 7.—Laboratory-constructed model of the EDM.

the housing of the light source can be seen. The whole instrument can be placed on any tripod of standard design.

Figure 8 shows the plane mirror which can be adjusted vertically to the line of sight by means of tangent screws. This is done when an assistant observes the light source of the instrument with the sighting telescope attached to the mirror. The instrument is calibrated immediately before and after each distance measurement. The two calibrations and the measurements can be completed within 7 minutes.

The routine of the measuring process is started by reversing the switch from "off" to "calibration." The scale of the measuring oscillator is calibrated, taking hardly more than 1 minute. Next, the instrument is switched to "measuring position" and by rotating a condenser knob the phase coincidence, or zero position of the galvanometer, is obtained. The corresponding scale division is read. Further rotation of the knob brings about another deflection of the galvanometer, which, however, is reduced to zero if, instead of the previous n wave length $(x+1)$ or $(x-1)$ complete wave trains fill out the measuring distance without remainder. The procedure can be extended in both directions, so that 4 to 5 independent measurements can be made. Thus, 4 to 5 frequencies are obtained or the wave lengths pertaining to such frequencies. Two such measurements are sufficient for computing the distances or for reading them from tables. The whole measuring process requires hardly more than 3 to 5 minutes. Then the switch is reversed to "calibration" and the instrument calibrated in the same manner as at the beginning, taking another minute. During this short interval generally no change occurs in the calibration data. If this should be observed during a longer duration of the measurements, the calibration value can be determined by interpolation. It is, however, simpler in this case to repeat the measurement including calibration which, as mentioned above does not require more than 7 minutes.

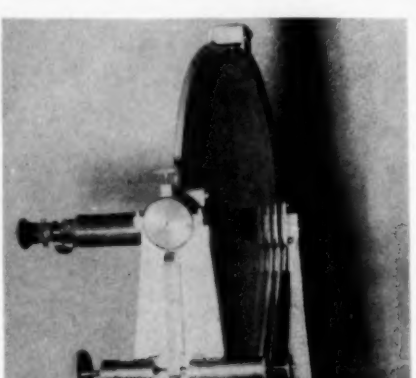


FIGURE 8.—Plane mirror with tangent screws for adjusting to the line of sight.

The results of a trial measurement are given below:

Meters
82.56
82.64
82.62
82.47
82.48
82.57
82.55
82.55
Mean 82.55 ± 0.025

The wide range of the measurements may be accounted for by the primitive optical structure of the experimental model. The diameter of the conic light beam at the receiver was 1.5 meters instead of 8 centimeters. The indication of the zero galvanometer therefore was only 2 units of the dial graduation because of the great loss in light intensity. This required a very difficult adjustment.

The results obtained thus far show that the experimental stage has essentially been concluded. The Askania-Werke, AG., Berlin-Friedenau,[1] have decided to manufacture the instrument in cooperation with the Institute of Applied Geodesy and to adapt it to operating conditions in field practice.

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[1] Bundesallee 86–89, American Sector.

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Electronic Brain Being Tested at Belvoir

An electronic computer which breezes through simultaneous equations and least squares has been developed by the Corps of Engineers' Research and Development Laboratories, Fort Belvoir, Va., and the Monrobot Laboratory of Morris Plains, N. J.

Called "Monrobot V," it will speed up the preparation of military maps by reducing the time required for complicated engineering calculations to a minimum. Tests have proved that it makes figuring faster, easier, cheaper, and more accurate than ever before.

The computer resembles a large office desk and weighs about 1,500 pounds. Equipped with shock absorbers to cushion vibration, it is rugged enough to be used in the field. For easy loading into a mobile laboratory, it can be separated at the middle into two sections.

Easy maintenance under field conditions is facilitated by the use of pluggable units, and a low power consumption of about five kilowatts makes it ideal for the Army's portable units.

The machine is designed to withstand dust and extreme changes in temperature and humidity, and has its own built-in cooling system.

Simple to operate, it also has a built-in keyboard which permits the entering of problems in their algebraic form. It is equipped with punch-tape facilities for automatic operation. Results may be printed on a paper tape eight inches wide, or punched out in the form of perforated tape. Its electronic "gray matter" can turn out trigonometric calculations to ten-place accuracy.

Monrobot V will undergo engineering tests at Fort Belvoir, where it will compute traverse, trig-traverse and three-point problems; make triangle, position and azimuth computations; convert geographic coordinates to UTM grid coordinates; compute spherical excess and trigonometric elevations; adjust geodetic trilateration and handle other related surveying problems.

Air Trails Maps: A Chapter in the Early History of Aeronautical Charts

By HELMUTH BAY

RAND McNALLY & COMPANY

COMMERCIAL AVIATION was born on August 12, 1918, when the U.S. Post Office Department inaugurated permanent airmail service between Washington, D. C., and New York. An experimental period starting May 15th of that year, during which U. S. Army planes and personnel did the flying, had demonstrated the practicability of such service. On that August day, therefore, the Post Office Department officially assumed responsibility for flying the mail.

The new Post Office division, comprising pilots, ground crews, and other civilian employees, was organized by Benjamin B. Lipsner, who was appointed first Superintendent of Airmail by Postmaster General Burleson. Planes selected for the operation were the Standard JR-1B and the Curtiss JN-4H, both powered with 150-horsepower engines. The pilots who flew the first commercial airmail were Max Miller, Edward Gardner, Maurice Newton, and Robert Shank.

During the first ten years of commercial air transportation there existed virtually no maps or charts which might aid the flyer in finding his way. So desperate was the need that road maps, railroad maps, and political maps were used. Such maps were of limited utility in the daytime, and for night flying they had value only for spotting the general location of cities and towns. Maps for plotting courses and accurately measuring routes were nonexistent. However, this lack was not too serious as most flyers of the period had little knowledge of scientific air-navigation techniques. Contact flying was the order of the day.

The problem of flying safely was nonetheless foremost in the minds of both airplane manufacturers and pilots. Instruments were designed to keep planes on course in cloudy or heavy weather. Fool-proof compasses, various types of altimeters, and wind-drift indicators were developed. Flying became more than just chauffeuring a plane and, as aerial navigation progressed, more accurate maps and charts were required for laying out courses and plotting aircraft positions while in flight.

A number of visits and phone calls from aviators brought forcefully to Rand McNally & Company's attention the need for good flight maps. This pressure led to the publication in 1928 of Air Trails Maps, the first set of maps covering the entire United States, designed specifically for the safe and accurate navigation of airplanes.

Distributing air-navigation maps to flyers posed a problem to the manufacturer. With the limited demand for such maps it was found that few map dealers would agree to handle them. To encourage dealers to stock the new Air Trails Maps, Rand McNally & Company decided to use as a base its Standard Indexed Pocket Maps which were well-known throughout the country. These maps, available for all States, were on varying scales, and showed railroads, cities, towns, and counties. They were constructed on the Lambert projection, which was ideal for plotting data and solving navigational problems. On this projection a great circle course could be shown by a straight line drawn between two points. Directions or bearings could be easily determined from lines of longitude with the aid of a protractor. A fairly complete pattern of rivers, streams, lakes, and shorelines was included on the series, as well as a large number of cities and towns.

The first step in preparing the Air Trails Maps was to compile a file of U. S. airports, of which there were fifteen to eighteen hundred in existence at the time, ranging from

excellent municipal fields to slightly improved cow pastures. To secure the desired data, Rand McNally mailed questionnaires to every airport, requesting full information as to facilities. Information sought included the correct name; distance and direction from the nearest city or town; its class, whether municipal, private, commercial, auxiliary, experimental, or intermediate; altitude and size of the field; whether or not it had landing lights; and the name of the owner or operator. From the returns a directory of airports in each State was prepared.

For practical reasons, the standard State map was printed on one side of the Air Trails sheet, while the verso carried a map overprinted with aeronautical data essential for its use as a navigational chart. On the latter, red tick marks were printed around the entire border at ten-and fifty-mile intervals as an aid to scaling and interpreting distance. Distinctive symbols indicated the several types of airport — municipal, restricted, commercial, and so on. Established airways were shown by straight lines, with the magnetic course and such aids as beacons and radio stations properly marked. Elevations for selected points were indicated by red crosses and figures. Lines of magnetic declination enabled the pilot to correct his measured true north bearing to the magnetic bearing. On later editions of the Air Trails Maps, aural ranges were added.

The index booklet, which accompanied each map, was enlarged to include the airport directory along with a discussion of existing aids to navigation such as beacons, radio stations, elevations, airways, and types of fields. Also included was an eight-page treatise on the "Elements of Practical Air Navigation," probably the first basic compilation on the subject published in this country. Thoburn C. Lyon, who supervised production of the Air Trails Maps, compiled the "Elements," under the direction of William E. Johnson, then chief cartographer of Rand McNally. The text, copiously illustrated with line drawings, tables, and diagrams, described the instruments needed for flying by dead reckoning. They were (in addition to the map, of course) a reliable watch, a magnetic compass, a bank and turn indicator, an air speed indicator, an altimeter, a climb indicator, and a drift indicator. There followed a discussion of methods and techniques for plotting a course on a map and determining its magnetic bearing. The flyer was further instructed in correcting for wind, computing ground speed, and correcting to course in flight, and briefed in identifying ground positions.

Air Trails Maps were eagerly purchased by pilots and others interested in flying and a number of airlines made them compulsory equipment on all their aircraft. The maps were available in all parts of the United States and the method of using them was easily learned with the aid of the legends, directories, and navigational discussions. The popularity and wide use of Air Trails Maps contributed much to drive home the fact that there was more to flying than just piloting an airplane.

Keeping the maps current was a costly maintenance problem for the publishers. New airports were being constructed everywhere, and existing ones were being enlarged or changed. Airways, with beacons and other aids, were extended or increased in number, and radio and electronic navigation aids were perfected and accepted. Consequently, when Mr. Lyon returned to the U. S. Coast and Geodetic Survey, in the early thirties, to assist in planning for and setting up specifications for the U. S. Sectional Aeronautical Charts, Rand McNally & Co., relieved of its responsibility, discontinued the Air Trails series.

The new official aeronautical charts initially included many of the basic features of the Air Trails Maps. The Lambert projection was retained, after a careful study of all projections, as was much of the navigational symbolism, distance scales, and general nomenclature. The principal difference was in the basic map content upon which the navigational data was superimposed. In the government series, the entire country was shown on a common scale. Terrain was depicted in hypsometric tints clearly indicating differences in altitude, while political boundaries and other nonessential data were omitted.

With the urgent need for aeronautical charts covering all parts of the world in World War II, air services of practically all allied nations adopted the standards of the Coast and Geodetic Survey Aeronautical Charts. However, because of the greater speed of new military airplanes, a scale of 1:1,000,000 was utilized rather than the 1:500,000 ratio of the U. S. Sectional Charts. Similar specifications were adopted after the war by the International Civil Aviation Organization, for international aeronautical charts for use by private and commercial pilots. Today, aeronautical charts for nearly all countries of the world are available on the 1:1,000,000 scale.

Cartography, New Australian Journal, Makes Debut

THE FIRST ISSUE of a new technical journal *Cartography*, published by the Australian Institute of Cartographers, is dated December 1954. The new journal, to be published semi-annually, is divided into three sections: (1) Bulletin, covering news of Institute affairs and of cartography in general; (2) Journal, containing original papers contributing to the science of cartography; and (3) Abstracts, including reviews of current cartographic literature.

The broad interpretation of the word "cartography" in Australia is made amply clear on the title page of the journal where the United Nations publication, *Modern Cartography—Base Maps for Modern Needs* is quoted as follows:

Cartography is considered as the science of preparing all types of maps and charts; and includes every operation from original surveys to final printing of copies.

The contents of the first issue, especially the Abstracts section, bear out this broad definition of the field of cartography.

A University Degree in Surveying—An Australian View

ALTHOUGH members are not unanimous on the matter, a consensus of opinion favours a university degree course as an introduction to the profession. It is unfortunate that through lack of students degree courses in surveying have lapsed at some State Universities. Probably this would not have occurred if the courses had not been optional as means of entry, and it appears that once decided upon, the degree course should, as soon as possible, supplant the pupil system. Some relic of the pupil system would remain, of course, in the compulsory field service which must be demanded of candidates, but the assumption by the Universities of the academic training at present acquired by the loose and haphazard methods of article pupilship can only result in great benefit to trainees and the profession in general.

At least some of the State Boards are anxious to be relieved of the burden of academic examinations and there is no doubt that improvements in general control and closer attention to the growing needs of the profession would result if the Boards were able to give such matters their undivided attention.

The impact on the profession and on the public by the entry of University trained graduates would be tremendous and would undoubtedly result in an ultimate improvement in conditions and status. The matter of prestige, as always, would remain an individual affair as every man, whatever his training, is himself responsible for the degree of prestige accorded to him.

In the introduction of degree courses, it should be our concern to ensure that the administration and tuition is held in the most capable hands, and as one would not expect, say, an orchestral conductor, however gifted he might be, to lecture to undergraduates on physics, one should therefore expect the teaching of surveying to be under the control of surveyors. With the complications of law and boundary definition, surveying ceases to be the precise academic subject it is imagined by many, and the need for experienced and mature teaching becomes evident.

The proposed introduction in New South Wales of a degree course at the University of Technology is awaited with great interest, and if surveying is treated as a profession in its own right and not as a somewhat tiresome appendage of civil engineering, there can be little doubt of its success.—Editorial in *The Australian Surveyor*, March 1954.

Scribe Coatings Blossom Out

By KENNETH R. DEARDORF

CHARTING TECHNIQUES OFFICE, CARTOGRAPHY DIVISION,
AERONAUTICAL CHART AND INFORMATION CENTER

THE MAKING of maps and charts has, of necessity, been influenced by limitations of the offset lithography process by which they are printed. Consequently, some of the most active avenues of cartographic reasearch have been directed toward simplifying preparation of final copy for lithography, or the approaches to it. The ultimate goal, perhaps, is to devise a means of making printing plates directly from map manuscripts or compilations.

Substitution of negative engraving for pen-and-ink drafting constituted a major advance. Subsequent improvements in materials and methods have pushed ever closer to the goal. Evolution in the color of coatings in which the engraving is performed represents one interesting phase of cartographic research. The traditional black, which was both photographically and optically opaque, has been replaced by coatings tinted in a limited range of colors. Although these colors were semitransparent, or translucent, light which passed through them was limited to wavelengths to which the photographic emulsions were not sensitive. Coatings of different shades and combinations of red, yellow, and green have been utilized with varying degrees of satisfaction. As the sheets served as negatives from which photographic copying was to be done (either to a film emulsion or directly to the printing plate itself), their coatings needed to be photographically opaque. Because this limited the choice of colors and degree of transparency, the usefulness of the coatings, from the standpoint of ideal engraving conditions, was also limited.

NEEDS OF THE ENGRAVER AND THE LITHOGRAPHER

White or transparent coatings were desirable as engraving and tracing mediums, but they could not be used because they transmitted all light wavelengths. Even the nonactinic colors which could be used were not ideal for photographic purposes. With some of these, the exposure timing, when making copies, is quite critical. Other colors have been baneful to the eyes and dispositions of those who worked with them. The necessity of working over a back-lighted surface has resulted in a certain amount of inconvenience, trouble, and expense with coatings of any color. A coating which would be ideal for the engraver as well as for the lithographer has been the objective of cartographic reasearchers.

R. H. Sovar of the Aeronautical Chart and Information Center has recently come up with an answer to this seemingly incompatible need. His successful method involves converting coatings which are initially ideal for the engraver to a state ideal for offset reproduction purposes. This is accomplished by a formula and technique for changing the colors of coatings and/or making them opaque while they adhere to the plastic sheet. The engraver is thus able to work with a coating of any color, or even a transparent one. After the sheet leaves the engraver it is put through a simple dye process which renders it opaque. It is then suitable for offset plate-making preliminaries, or for preparing a printing plate. The new formula and technique, which open a wide range of possibilities, have been named "Convert-a-Cote."

INCREASING THE OPACITY OF COATINGS

Coatings of colors in current use are said to be photographically opaque. Their opacity is in some cases merely relative, however, and is dependent on critical timing of exposure when copying. Treating drawings engraved on such coatings by the Convert-a-Cote process increases their opacity to such a degree that exposure time is no longer critical, and can be extended for many times

the optimum without danger of "burn-through."

Images imprinted on a white coating as a guide to the engraver can be made to stand out with maximum clarity by the Convert-a-Cote process. Moreover, a white coating does not require back-lighting to bring out the engraved work. In fact, back-lighting is undesirable, as there is little contrast between illuminated scribed lines and illuminated coating. However, if the white sheet is placed upon a black background (a piece of black paper on an ordinary drafting table) the engraved lines stand out in black with great contrast and distinctness against the otherwise white sheet. After the engraving is completed, the white sheet can be dipped in black Convert-a-Cote dye solution to produce a negative for photographic reproduction.

Transparent coatings also offer interesting possibilities. A sheet with a transparent coating can be placed directly over source material or "pull-ups," and selected detail traced with an engraving tool. The steps of compiling and making a final reproduction negative are thus combined. After the desired detail has been "scribe-traced," the engraved sheet is made opaque by immersion in Convert-a-Cote dye solution.

Great as are the potentialities of Convert-a-Cote, there are still complications to be ironed out; but Convert-a-Cote obviously brings us closer to the goal of making compilations in the form of color-separation drawings.

CONVERT-A-COTE TECHNIQUE

The two most significant features of the Convert-a-Cote process are (1) its simplicity and (2) its versatility. The dyeing, as has been mentioned, is accomplished by immersing the coated sheet in a dye solution. The formula for black is as follows:

9.6 grams Calco Methyl Violet Base [1]
4.8 grams Calco Bismarck Brown HM [1]
1.0 quart denatured ethyl alcohol

[1] Trade name for product of American Cyanamide Co., Calco Chemical Division, Bound Brook, N. J. Other dyes having similar characteristics should be equally suitable.

The solution is poured into a tray large enough to contain the sheet to be dyed. The sheet is eased into the tray, coating upward, until it is completely covered by the solution. The time it remains in the solution depends on the intensity of coloration desired. Two to five minutes is the average. A longer immersion results in absorption of a greater quantity of dye and consequently a darker hue to the sheet. The original color and thickness of the coating must also be considered in determining the length of time the sheet is immersed. Upon removal from the tray, the sheet is rinsed briefly in water and surface moisture is wiped off. It is dry and ready for further use within a few minutes.

A thick coating will absorb more dye and become more opaque than a thinner one of the same original color. With certain very pale initial tints, transparent coatings, or exceptionally thin coverings, Convert-a-Cote may not provide a completely non-critical opacity. When photo-copying from such dyed engravings, exposure time becomes significant, and must be carefully regulated, as for some of the coatings in current use.

The dye, in the formula given above, has no effect on Vinylite. Consequently, if the coating is on Vinylite sheeting, there is no danger of staining the engraved image, which remains clean and clear. While it has been assumed in this discussion that treatment will take place following engraving, it should be noted that the dyeing operation does not appear to affect the engraving qualities of the coating in any way. A sheet may, therefore, be dyed either before or after it is engraved, whichever suits the circumstances.

The Convert-a-Cote process has not been tested on a wide variety of coatings. As it was developed for its possibile applicability to procedures at the Aeronautical Chart and Information Center, experiments were naturally slanted toward the coating in use there. The adaptability of the process to other coatings, or their adaptability to it, should be easily determined by users or makers of specific coatings.

By freeing the cartographer from the requirement of opacity in the engraving coatings with which he works, the Convert-a-Cote process appears to have considerable significance, and to have opened up new fields for exploitation.

Airborne Anomaly Maps

THE United States Atomic Energy Commission has recently made available its series *Airborne Anomaly Location Maps* to all who wish to subscribe. These maps present the results of reconnaissance flying of certain areas during tests for radioactivity. They delineate areas of unusually high radioactive count.

The maps are available on a subscription basis from the Superintendent of Documents, Government Printing Office, Washington 25, D. C., at $8.00 per year for the entire group of maps, regardless of the area flown.

Each new group will be mailed the 15th day of each month and will contain a varying number of maps. Subscribers will receive all maps, regardless of area. Groups dated October 15, 1954, or after will be sold separately if desired; the prices will vary according to the number of maps issued each month. Individual maps will not be sold separately. For information regarding maps issued prior to October 1954, apply to the Atomic Energy Commission, Raw Materials Division, Attention: Mr. W. Waylett, 1901 Constitution Avenue, N. W., Washington 25, D. C.

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Control Surveys as Applied to Engineering Projects

(A Panel Discussion)

THE PANEL MEMBERS

Left to right: Prof. C. A. Egner, R. E. Wagstaff, M. O. Laird, B. E. Beavin, Jr., E. D. Morse, and E. C. Houdlette.

This panel discusion was presented at a session of the Control Surveys Division during the Fifteenth Annual Meeting of the American Congress on Surveying and Mapping, at Washington, D. C., March 11, 1955. Prof. Milton O. Schmidt, Division Ctairman, presided over the session. The discussion is presented here in condensed form, as adapted from the stenotypist's transcript.—EDITOR.

CHAIRMAN SCHMIDT: We have an excellent panel which will consider the application of control surveys to a variety of engineering projects.

Many of us who come from different parts of the country know that we have problems with regard to impressing on others the value of using the national networks of horizontal and vertical control.

We are going to hear from the various panelists regarding some of the peculiar problems that they have encountered and how they have been able to persuade others to make greater use of available horizontal and vertical control.

Heading the panel as moderator is Carl A. Egner, Professor of Photogrammetry and Geodesy at Purdue University.

PROFESSOR EGNER: Our subject, "Control Surveys as Applied to Engineering Projects," is one that is quite close to me because of my long service with the U. S. Coast and Geodetic Survey. I have had opportunity to witness an amazing change in emphasis and direction in the establishment of the horizontal control network in our country. In the early years it was necessary to execute many long and extensive arcs of triangulation. Today, the primary emphasis is on area triangulation which fills in the gaps between the major arcs and provides stations of maximum usefulness to the local surveyor. It has been very gratifying to see private and commercial agencies making use of the network of control. Some of their methods are conventional; others are quite ingenious. All bear the hallmark of quality, attesting to great pride in accomplishment.

We have on our panel several able practitioners of the surveying art, each practicing in a distinct field. In this group we have a State surveying administrator, a consulting engineer, a representative in the field of international telephonic communication, an engineer employee of a large public utility firm, and one greatly experienced in down-to-earth surveying as practiced in a nearby community.

E. C. Houdlette, our first speaker, is Director of Surveys, Massachusetts Department of Public Works, Boston, Mass.

Mr. Houdlette, What did you accomplish under the WPA in the establishment of geodetic control in Massachusetts?

MR. HOUDLETTE: Under WPA, with the wonderful cooperation of the U. S. Coast and Geodetic Survey, we were able to complete the first- and second-order arcs of triangulation in Massachusetts and also execute approximately 5,000 miles of second-order traverse.

PROFESSOR EGNER: What have you been doing since then to extend this control?

MR. HOUDLETTE: Since then we have, in the State Highway Department, two regular geodetic survey parties that do nothing but extend this control, and we have four computers in the main office. All field parties and our regular survey workers are instructed to use the control which the geodetic parties provide.

In the construction of our expressways we stipulate that the contractor is to put monuments in the center strip at the point of curvature and the point of tangency of each curve and also at maximum intervals of 1,000 feet along tangents. After the job is completed and has been accepted, our geodetic-control party runs a traverse through all of these monuments. That traverse is then adjusted so that we obtain the "X" and "Y" coordinates of stations no more than 1,000 feet apart along the entire length of the expressways.

PROFESSOR EGNER: I would like to have you tell us what difficulties you had in getting the State coordinate system adopted in Massachusetts.

MR. HOUDLETTE: In Massachusetts, we formed a committee consisting of engineers and a member of the Bar Association. We studied the model bill which was furnished by the Coast and Geodetic Survey and prepared legislation which fitted the State of Massachusetts. I introduced the bill in 1941 to the Legislature. At the time of the hearing we had present representatives of the Northern Association of the American Society of Civil Engineers, the Boston Society of Civil Engineers, and the Massachusetts Land Court. All of them favored the bill. We didn't have trouble passing the bill. I think, when the bill was read in the House, there were not more than half of the legislators present and they weren't paying much attention to it. After the bill passed—it went right through—I did get an interesting letter, and I want to read it because it was most unusual.

It is dated March 5, 1941, and reads:

"On February 28th I signed a bill defining and authorizing the use of a system of applying coordinates and designating station positions on the surface of the earth.

"When the bill was submitted the technical phraseology therein contained excited my interest, for I never recalled having a bill presented to me which contained, to a layman, such mystifying phraseology.

"When its general purpose was ascertained, I was glad to sign it.

"I discovered that you have taken a prominent part for a number of years in this activity in this State.

"I thought you would like the pen with which I signed the bill, and I am enclosing it herewith."

And it is signed, "Very truly yours, Leverett C. Saltonstall, Governor of Massachusetts."

PROFESSOR EGNER: Thank you, Mr. Houdlette. We will now hear from E. D. Morse of the Houston Lighting and Power Company, Houston, Texas.

Mr. Morse, what engineering use does your company make of control surveys?

MR. MORSE: It has been our practice for a good many years to integrate surveys for cross-country transmission lines with the national control network. If at all possible, we tie each such project to the Coast and Geodetic Survey first-order triangulation network. It has been our experience that on the whole this has been very beneficial to us, and in most cases more economical than former practices. Before the use of State coordinate control in our system, which comprises some 5,000 square miles, a great deal of time and money was expended in route studies. We had to resort to such procedures as the use of rockets in getting good lines in timbered areas. Through the use of State plane coordinates and available air photography, it was possible to obtain the shortest and most economical route.

PROFESSOR EGNER: Did you meet with any legal problems in the use of State plane coordinates?

MR. MORSE: Not very many. Some ten years ago I initiated the program of using State plane coordinates in all our legal documents pertaining to the purchase of fee lands and rights-of-way. We purchase as many as a thousand parcels of land each year. In a very small percentage of these cases, the attorney for the seller objects to the use of State coordinates. Since the time I initiated the program, I have had our right-of-way engineer and our various right-of-way agents refer the attorney to me. I keep a copy of the bill in my desk, with some certain portions underlined, and I read it to the complaining attorney. In most cases the attorney finally concedes that the State coordinate land description has merit.

Some objections that we get are perhaps well founded. One of these is that the distance from the nearest Coast and Geodetic Survey station is excessive and our surveyor had to run too many miles of traverse in order to obtain a good tie. I usually try to find out who the objecting engineer or surveyor is and sometimes I am able to convince him of the quality of our work and he will accept it. By and large, we don't attempt to force these legal descriptions on anyone who complains.

PROFESSOR EGNER: What order of accuracy do you obtain in making these connections, and do you find that a high order of accuracy is wise not only from a cost standpoint but in other ways also?

MR. MORSE: Well, we are rather fortunate in our particular area in that we have relatively flat terrain to traverse. By the use of a few precautions, we normally obtain position checks between first-order Coast and Geodetic Survey triangulation stations of 1 part in 10,000. If the terrain poses something of a problem, we are satisfied with less than that. However, we never accept less than 1 part in 5,000.

PROFESSOR EGNER: What cost does this involve?

MR. MORSE: Do you mean the additional cost over that of ordinary methods?

PROFESSOR EGNER: Yes.

MR. MORSE: I was asked the same question a few years ago by a member of our management department and I made a rather careful study of costs. As nearly as I can determine, the additional cost was something less than ten percent. I made that analysis about ten years ago. I was gratified two or three years ago to see a much more extensive analysis by Sol Bauer, of Cleveland, who arrived at substantially the same conclusion for his particular surveying work.

PROFESSOR EGNER: Thank you, Mr. Morse.

We will now hear from Max O. Laird, who is Overseas Equipment Engineer for the American Telephone and Telegraph Company and has had some very interesting experiences in establishing locations and in the orientation of many of the large towers used for transatlantic telephonic communication.

Mr. Laird, what systems of horizontal control did you use in your initial locations for these tall towers along the Atlantic seaboard?

MR. LAIRD: Initially we started out with very little control. We do require approximate position and we had fairly good azimuths for the orientation of the antennas which we aimed at overseas points.

Originally we obtained positions by scaling from maps and made observations for azimuths. However, the extent of these installations was not fully realized at the start. We usually started out with a new star observation for each antenna, but it soon proved to be more efficient to establish local control nets. In the last ten to fifteen years these have been extended from the Coast and Geodetic Survey system and by third-order methods. We now follow the practice entirely and use the State plane coordinate systems.

PROFESSOR EGNER: What order of accuracy do you consider necessary in the location and orientation of these radio towers?

MR. LAIRD: Many of the items in the project plan can tolerate substantial errors and still be satisfactory. Radio signals

do not follow the great circle pattern at all times so that it is necessary to have some beam width in these antennas. The amount of error that would be restrictive in ordinary surveying would not be an important factor in the location and orientation of these antennas.

However, at the radio stations there are a great number of antennas, transmission lines, and underground utilities which frequently are very close together. Hence, you need to know the relative positions of the services already in place with respect to the new staking, and that requires good horizontal control because these stations usually cover from 250 to 1,000 acres. A few extend over 3,000 acres. Generally, third-order accuracy is sufficient for our work, and that is what we attempt to obtain.

PROFESSOR EGNER: Thank you very much, Mr. Laird.

Now I wish to introduce B. E. Beavin, a consulting engineer and surveyor from Baltimore, who has had exceptional experience in horizontal control surveys.

Mr. Beavin, in your private practice and consultation work, what use do you make of established control and what accuracy do you find expedient to use in extending that control throughout your own projects?

MR. BEAVIN: We use control surveys as the backbone of practically every survey we make. The only exceptions are the small ones and those which are so far removed from any available control that the cost of tying them in would be absolutely prohibitive.

As to accuracy, we have some very brief specifications for four classes of traverse, viz., A, B, C, and D. The closures for these are as follows: A, 1 in 25,000; B, 1 in 10,000; C, 1 in 5,000; and D, 1 in 2,000.

Also, we have two general types of surveys. One type is used to cover a large area with a high density of stations scattered throughout the area. In this case the traverses and triangulation around the perimeter of the area are Class A; between them are Class B traverses; and finally Class C work. If the work is consistent, even the Class C traverse stations retain a very high order of dependability.

In the case of route surveys, we frequently start at one station and run for several miles before we are able to tie to another one. We find it advisable to keep the work of high quality and usually use the Class B traverse.

PROFESSOR EGNER: Now, here's a question that I think is very important. In view of the purposes and the ideas behind the program of all the large Federal surveying organizations in establishing control over the country, it is obvious that they are very much interested in making that control most useful to all private engineers.

Do you have any recommendations as to anything that could be done by these Federal organizations to make their network of control more useful to the local surveyor?

MR. BEAVIN: Of course, there is one very basic one, and that is that we need control stations more frequently than we ever had before. We have "missed the ball" through the years by making a lot of public surveys and neglecting to perpetuate them or make them with proper regard to accuracy. The longer we put off making up our minds that we are going to make every survey count for greater density of control, the longer this economic waste persists.

I think that—starting from the top and working down, so to speak—the Federal government should encourage, by every means possible, the State boards and bureaus that have to do with control surveys, and also extend that encouragement to the local groups that are doing control surveys.

I believe that if we are going to have the control filled in between the present rather sparse control, it will have to be done by other than the survey parties that are on the payroll in Federal and State activities. We have been hoping for many years that those activities would receive adequate appropriations. They have not received them. So I have recently been thinking that, if careful specification requirements for both horizontal and vertical control were outlined and a program of having some of that work done by contract by qualified engineers and surveyors were outlined, a greatly needed forward step would be taken.

I will reiterate another belief; that every new survey of any extent made by a public

body should add to the total fund of control data available for everyone's use. Such data should be filed by some central State agency and perhaps processed there as to its reliability. The results of the more important surveys should be given to the Coast and Geodetic Survey for incorporation in their publications.

PROFESSOR EGNER: Thank you, Mr. Beavin.

The next speaker on the panel, R. E. Wagstaff, from nearby Virginia, has had in recent years a most interesting case of boundary relocation. He holds the position of County Commissioner in Virginia and was the Coast and Geodetic Survey's primary contact in running a survey along the Fairfax-Loudoun County boundary line.

This survey presented a few unusual problems in boundary relocation, and resulted in the shifting of a number of homes, schools, shops, etc., from one county to the other.

Mr. Wagstaff described this survey in a paper which he gave at the Herndon (Virginia) Lions Club meeting not long ago. Rather than ask him specific questions on this subject, I am going to ask him to repeat, in part at least, the address that he gave before the Lions Club.

MR. WAGSTAFF: A history of the line between Fairfax and Loudoun Counties might go back to 1648 when all the land between the Rappahannock and Potomac Rivers was set up in one county, Northumberland County. One ambitious chap even took up a piece of land fronting a short distance on the Potomac River and extending westward to the Sea of California. When Fairfax was cut off from Prince William in 1742, it extended westward to the headsprings of the Potomac. Likewise, in 1757, when Loudoun was cut off from Fairfax, it extended to the headsprings of the Potomac. Loudoun was not cut off from Fairfax at the present line, but at Difficult Run. Thus, Fairfax was much smaller than it is now.

Fairfax County and the part of Loudoun County below Goose Creek was settled by the "Twelve Families of Virginia," the upper crust, or "The 400." They were Church of England men, accustomed to rule any society in which they lived. In Loudoun County they found themselves in contact with the Quakers who had come down across Maryland from Pennsylvania and settled in upper Loudoun.

The Quakers outnumbered them and had a totally different outlook on everything. Being unable to control the Quakers, the Church of England people, after the Revolution, petitioned the Legislature for many years to create a new county out of lower Loudoun, upper Fairfax, and a part of Prince William, to be called Cameron, after the Episcopal parish of Cameron.

Failing in the effort to have the county of Cameron created, they petitioned to have the lower part of Loudoun—where there were but a few Quakers—cut off and rejoined to Fairfax.

This was done in 1798, and the survey of the present Fairfax-Loudoun line was completed in April of that year, thus adding to the confusion.

A plat of this survey is still on record at Fairfax. The line runs from the mouth of Sugarland Run to Carter's Mill on Bull Run. Since the beginning point of this survey is an unmarked natural rock on the river and the ending point is a blazed oak on the bank of Bull Run, it isn't likely that any intermediate marks were set.

Our next information on the county line is contained in two entries in a Fairfax Court Order Book dated 1877. The handwriting is well nigh illegible. These two entries show that three men from each county were appointed, and a survey, or at least some part of a survey, was made; that majority and minority reports of the Commission were filed. Neither the majority nor the minority report is recorded and there is no inkling of what either contained.

But apparently the survey was completed. The man who did this surveying was an all-round character. He was a merchant, postmaster, undertaker, and surveyor. He set his mark stones apparently as he went along. When he was about half-way through the survey, according to present-day figures, there was about 800 feet left over to fall in Loudoun County. Apparently the survey

stopped there. However, it was not accepted by the Court, which was necessary before a survey line could become a county boundary.

Since neither Court approved the survey, no one seems to have paid any attention to it. The town of Herndon was created two years after the survey of 1877 and the town limits extend to the county line, but they do not go to the survey line of 1877. They stop at the old county line surveyed in 1798. The railway survey, showing the county line, checks very closely with the town limits and with the 1954 survey.

While the 1877 Commission set stone markers, they apparently neglected every other phase of the survey.

In 1911 and 1912 the Geological Survey resurveyed this area. This is the first time the 1877 survey was shown on any map—38 years after the survey. In thus moving the county boundary, the Geological Survey did not move the town limits of Herndon, although they are one and the same by statute. The town limits of Herndon remained at the old 1798 survey line.

Since 1915 the confusion over the county line has mounted by leaps and bounds. After months of study the 1954 Commission, on the advice of two courts, threw the 1877 survey out completely as of no value or standing in court and complied with the letter of the law in setting up the line.

The U. S. Coast and Geodetic Survey was called upon to triangulate this area. It started in Maryland, went across the two counties, into the adjoining counties, triangulated more than 100 square miles, and gave us some 45 coordinate points, 8 of which were directly on the county line. Since the time the Coast and Geodetic Survey defined the line, additional points along the boundary have been set from these eight points by private surveyors.

Fairfax County has platted the line on photos and maps and released 4.5 square miles, nearly 3,000 acres, of land to Loudoun County. One hundred forty-seven pieces of property were thus transferred, wholly or in part, along with a good 5 miles of roads, to Loudoun County. The Commission had hoped that someone would institute a suit to test the boundary. Two men consulted lawyers, the lawyers consulted surveyors, and they both decided it wasn't worth while. The area is developing rapidly now, and further triangulation will be needed there. We feel the triangulation work performed by the Coast and Geodetic Survey will be of great service to the surveyors there.

New Optical-Reading Clinometer and Pointing Compass

TWO NEW INSTRUMENTS for preliminary or reconnaissance surveys, topography, or claim location, are being produced by Suunto Oy, a Finnish precision-instrument manufacturing company. The optical-reading clinometer incorporates three graduated scales: degrees (or grads), percent, and a non-optical scale for close quarters. Readings can be made directly to 1 degree or 1 percent and accurately estimated to 10 minutes or 1/5 of 1 percent.

The pointing compass or pocket transit has 2 scales. The optical scale is calibrated in degrees (or grads) and can be estmated to 10 minutes of arc. Both instruments are pocket-size, of light-weight metal, and designed for easy reading and use with one hand. The working parts are centered on self-lubricating sapphire bearings. Object sighting and scale reading are simultaneous.

Detailed information concerning these instruments can be obtained from the Imperial Trading Co., 1116½ North Western Ave., Los Angeles 29, Calif.

Establishing a Line by the Double-Line Method

By CURTIS M. BROWN

DANIELS, BROWN & HALL, SAN DIEGO, CALIF.

THE PROBLEM of establishing a true line in hilly country, where points are not intervisible and the distance is not needed, is simplified by using what I call "the double-line method." In figure 1, line *1* and line *2* are run simultaneously as random lines from corner *A*. The direction of line *1* is run as nearly as possible in the direction desired; this is usually accomplished by using a compass or by guessing. Line *2* is run so as to diverge from line *1* and attain about one hundred feet spread at corner *B*. First, the transit is set up at corner *A* and points *3* and *4* are set. The transitman moves up to point *3*, sights back on *A*, plunges over and sets point *5*. Next he moves over to point *4*, sights on *A*, plunges over and sets point *6*. After moving up to point *5*, he sights on point *3* and sets point *7*; likewise, he moves over to point *6* and sets point *8*. Points *7* and *8* must be adjusted so that they form a straight line with point *B*. The angle *A8B* (any angle is satisfactory) and the distances *X* and *Y* are measured. Going back to point *4*, point *3* is adjusted on line *2* o that line *4–3* is parallel to line *8–7–B*. After measuring the distance *K*, point *9*, a point on the true line, is set by the following proportion:

$$\frac{J}{K}=\frac{Y}{X}$$

$$J=KY/X.$$

The double-line method is exceedingly handy to use in establishing the center of a section where all other quarter corners are known. Two sets of double lines are run, one set north and south and the other east and west. The center is then set by intersection. Since normally only one quarter is surveyed for a client, the extra work involved in measuring the whole section is avoided.

The usefulness of the double-line method is also illustrated in figure 2, where the distance covered in one day was about 7 miles. Two random flags (designated as *10* and *11*) were set on the peak shown. Lines *1* and *2* were established by setting up on a hill behind corner *C* and setting points *E* and *F* by wiggling in between corner *C* and the two flags on the peak. Next, by setting

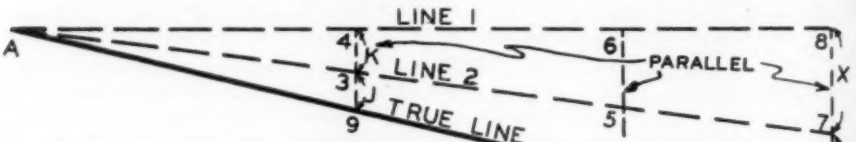

FIGURE 1.

up on the peak at points *10* and *11*, points *12* and *13* were set by plunging over. After measuring distances *X* and *Y*, point *14* on the true line was set by the above proportion. Returning to points *E* and *F*, the true line at *G* was established by wiggling in between corner *C* and point *14* on the true line. Since the distance was great and the terrain rough with numerous trees and obstructions, we estimated a savings of five field days.

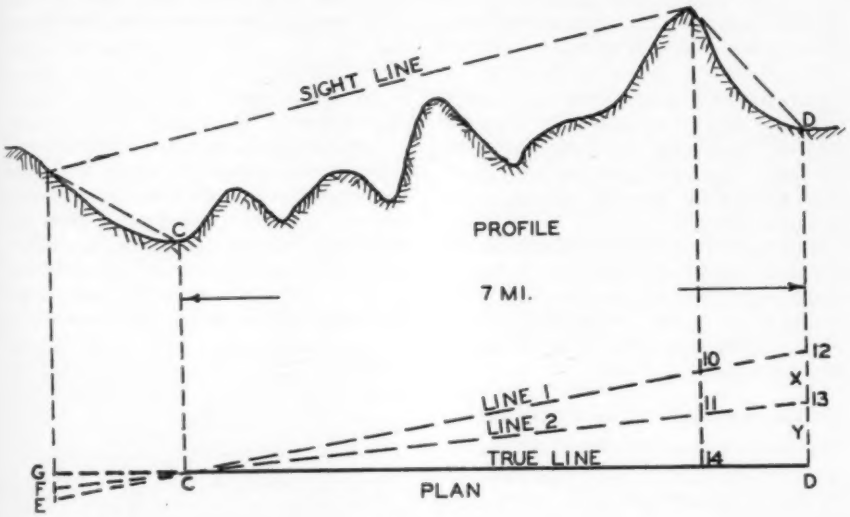

FIGURE 2.

ACSM "Gets Around"

President Higbee represented ACSM at the VI General Assembly of the Pan American Institute of Geography and History and the VII Pan American Consultation on Cartography, held jointly from July 25 to August 6, 1955, in Mexico City.

The attendance of our President at these meetings was the result of a formal invitation from the Secretary General of the Pan American Institute of Geography and History.

At the Commonwealth Survey Officers Conference, held at the Department of Geography, Cambridge University, Cambridge, England, August 15–24, 1955, ACSM was represented by Col. Gerald Fitzgerald, Chief Topographic Engineer, U. S. Geological Survey, and Past President of ACSM.

In a letter to Brigadier Martin Hotine, Chairman of the Conference, Secretary Dix transmitted, on behalf of the officers and members of ACSM, our best wishes for a successful meeting and, at the same time, officially designated Colonel Fitzgerald as ACSM's representative at the Conference.

Use of the Subtense Bar

By H. P. TANNER

WILD HEERBRUGG INSTRUMENTS INC.

EDITOR'S NOTE:—This paper is based on the stenotypist's transcript of Mr. Tanner's extemporaneous remarks. The equipment illustrated was set up in the meeting room and Mr. Tanner demonstrated its use as he spoke.)

THE WILD subtense bar is an accessory which has been used quite extensively, particularly by Federal agencies, for optical distance measurement. Interest in this method has been growing in the past few years.

Essentially, the method is to measure the horizontal angle subtended by a bar of known length at an unknown distance away. This distance is then determined from a previously compiled table, either in feet or meters as desired.

OBSERVATIONAL PROCEDURE

In demonstrating the use of the equipment, I am going to ask you to imagine that we are on a traverse course. This is our instrument station; we have set up the theodolite over the initial traverse point; the instrument which is mostly used for this purpose is the Wild T–2 Universal Theodolite, reading directly to one second. (*See* figure 1.) The rodman has set up the subtense bar (fig. 2) over the first point in the direction to be traversed. As you noticed when it was set up, the bar folds in half for transporting. Each of the metal tubes composing the bar encloses an invar wire having one end fixed directly to the hinge-abutment. At the other end, the tension of the invar wires is governed by springs connected to the metal tubes. The sighting targets, protected from damage by strong casings, are affixed to the invar wires. The distance between the targets is exactly 2 meters. Any expansion or contraction of the metal tube will not affect this distance since the invar wire to which the sighting targets are fastened has a very low coefficient of expansion. Also, damage to the outer metal tubes will not change the 2-meter distance

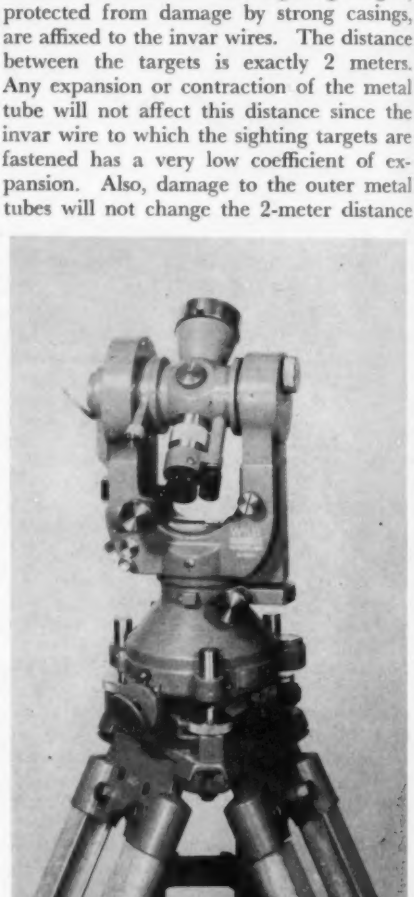

FIGURE 1.—Wild T–2 Universal Theodolite reading directly to 1 second, used for subtense-bar measurements.

Presented at the Fifteenth Annual Meeting, American Congress on Surveying and Mapping, Washington, D. C., March 9–11, 1955.

See also "Trig-Traverse," by Joseph G. Kelley, SURVEYING AND MAPPING, July–September 1950; "Map Control by Photo-trig and Subtense Bar," by Emmett J. Coon, SURVEYING AND MAPPING, January–March 1952; and "The Use of the Subtense Bar," by Michael V. Smirnoff, M.S., C.E., SURVEYING AND MAPPING, October–December 1952.

between the targets since the invar wire hangs free in the interior of the tube.

The subtense bar is leveled with three footscrews, using a circular level. The rodman then rotates the bar so that it is exactly perpendicular to the line of sight of the theodolite. To effect this, the bar is equipped in its center with a sighting telescope mounted on a hinge and at right angles to the bar, which is pointed at the telescope objective of the theodolite. Since the subtense bar is frequently used at night, it is internally wired for electrical illumination. When the battery box is used, a circular window in each of the sighting targets lights up.

After setting up the theodolite and subtense bar, the angle subtended by the sighting targets at the ends of the bar is read by means of the theodolite. The accuracy obtained depends on the quality and condition of observations, and the error is proportional to the square of the distance measured.

ACCURACY OF THE METHOD

To obtain some comparative data, a test was made last fall before the Northern Virginia Association of Land Surveyors. Several distances were measured on a very accurately taped course and I would like to give the results of that test.

The first distance measured with the subtense bar was approximately 480 feet and the accuracy obtained in relation to the taped length was 1 in 8,600. This result was obtained under very favorable observation conditions by first pointing the theodolite at the left-hand target of the bar and measuring the angle to the right-hand target. The instrument was then reversed and pointed at the right-hand target and the angle to the left-hand target was read. In each observation the mean between the two angles obtained was taken; in each measurement the angles were within two-tenths of a second of each other, which explains the good results obtained.

Following the first measurement, the next

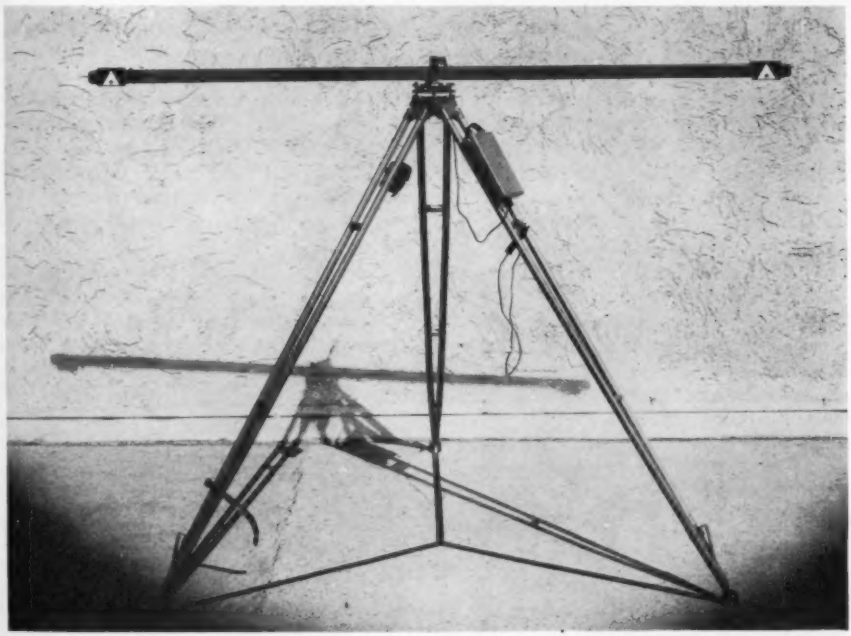

FIGURE 2.—Wild Invar Subtense Bar equipped with battery box for night illumination of targets.

distance of 316 feet was obtained with an accuracy of 1 in 13,000. Another distance of approximately 350 feet was determined with an accuracy of 1 in 11,000. The same procedure was followed throughout.

The accuracy can be increased by reading several sets of angles. The question of economy in relation to the accuracy required dictates how many sets of angles are taken. One of the main advantages of the subtense-bar method is that distance measurement is possible over rough terrain which might be impossible or impractical to tape. The subtense-bar method requires only a clear line of sight since it is necessary to see the bar within a path of 2 meters. It can be used to bridge gulleys, sight across rivers, and measure very steep or otherwise inaccessible slopes.

The second very important consideration in evaluating this method is the fact that the direct horizontal distance is always obtained with a subtense bar. The horizontal angle, which is measured between the two sighting marks on the bar, remains constant regardless of whether the bar is above or below the theodolite. (*See* figure 3.) Therefore, there is no need to apply a slope correction.

The third point I would like to mention pertains to the wide range of the method. In the distance table furnished with the subtense bar, the cosine of one-half the subtended angle is computed and distances in feet or meters are read directly. This table, therefore, serves as a very useful key in organizing a survey and determining the length of the sights, depending on the desired accuracy.

As you have noticed, the center part of the subtense bar is provided with a sighting point intended primarily to be used for trigonometric leveling. After the horizontal-angle measurement between the outside sighting targets is made, a vertical-angle reading on the center point of the bar can be taken. From this vertical-angle measurement, elevations can be computed in the office if a bench mark reference is available.

FIGURE 3.—Geometry involved in subtense-bar measurements.

O = theodolite
b = subtense bar
Z = point determined
Z^1 = horizontal projection of point determined
OL and OR = lines of sight
OL^1 and OR^1 = horizontal projections of lines of sight
E = measured angle
d = horizontal distance

Users of the subtense-bar method have pointed out that fewer personal errors are encountered than in taping practice. The equipment will yield exacting results under good observation conditions and the personal errors in operating it may be assumed to be smaller than those which may occur in taping. Of course, the subtense-bar method is not a cure-all. It is essentially made for measurements with third-order accuracy. Most users have, in fact, ascertained that an accuracy of 1 in 5,000 can be obtained over sights of approximately 500 feet under good observation conditions. In night work this can be extended. The Corps of Engineers obtained 1 in 5,000 accuracy over about 600 feet in night observations.

Discussion

LORING H. JACOBS (Massachusetts): Mr. Tanner, would it be possible to increase the length of the bar to 10 feet on either side of the center? Would it be practical and would it add to the accuracy?

MR. TANNER: It most certainly would,

but, unfortunately, at this point there is no commercial bar available that is longer than 2 meters, but some firms have made their own subtense bars. One firm manufactured a bar 30 feet in length, and in Texas bars even longer have been used.

MEMBER: How many readings do you use to obtain 1 in 13,000 accuracy?

MR. TANNER: That would depend on the distance. From results based on tests with very accurately taped distances, you can obtain 1 in 13,000 over a single sight of 300 feet, and the test I spoke about which was held in northern Virginia did obtain this accuracy with just two sets of angles measured.

MR. PRYOR: You gave results on the readings for specific lengths as 480 feet and 316 feet and 350 feet. That to me is only part of the answer that we need. What are the results of your tests when you have actually run a closure on traverse which, of course, would take into account the bearings as well as the individual distances, and how rapidly and accurately can a traverse be run of, say, a length of 1 mile, and then 10 miles, and so on? Have you any results on such tests?

MR. TANNER: No, I have no factual data on such a test having been made. Several studies are being conducted at universities to determine the time a comparable distance measurement with a subtense bar would take as against precise taping, but so far these studies have not been completed.

MR. EWALD (Massachusetts): A recent issue of the journal had an article on the telemeter used in conjunction with the subtense bar.[1] They had run closures and I wondered what the difference was in using the telemeter and using the equipment you have described.

MR. TANNER: The telemeter is a distance-measuring device based on the glass-wedge principle, and it utilizes a set of horizontal-distance rods. It is not an angle-measurement device. A different optical principle is used, and that method is more applicable for topographic work over short distances. The maximum distance you can sight with telemeter devices is 120 meters.

MR. WATTLES: (California): There has been some use of the subtense bar in California, and we find the conditions about as follows: In congested areas the use of the subtense bar for measuring the normal distance of 300 or 400 feet is a little bit ineffective. Everybody wants to crowd around and see what it looks like and you also have traffic and other things. In the suburbs, and in areas that are open, it is reasonably satisfactory. You get results with the accuracies that have been stated. It so happens that, in congested and urban areas particularly, we are required to produce an accuracy of better than 1 in 10,000 consistently by reason of the property-survey conditions and the land markers and subdivision requirements. So the use of the subtense bar under such circumstances is hardly satisfactory. We do find that, in longer-range distances up to 1,000 or 1,500 feet, and even as high as 3,000 feet over rugged terrain particularly, it is very very helpful as against taping, especially if the ground is covered with brush and trees. It is essentially satisfactory in establishing ground-control points for photogrammetric purposes because the scale at which the pictures are taken and the reductions for photographic purposes, and so on, allow a limit of down to 1 in 2 or 3 thousand in certain cases. It is very rapid for that reason. We haven't made precise tests, but we have made enough tests to show that substituting the subtense bar for stadia, or even for rough triangulation where sometimes the establishment of the base line is a little difficult, we can use the subtense bar to advantage.

MR. HOKE (Baltimore): We have found the equipment most useful in a recent job where there were about 8 or 9 bridges to be replaced. There were streams and valleys and railroad tracks and we had to get accurate centerlines transmitted to the bottom of the stream under the bridge. That was our solution and it worked out very beautifully.

MR. BALDWIN (Malverne, Long Island): Mr. Tanner, would you explain about the expansion and contraction?

MR. TANNER: Inside this metal tube we have an invar wire which is carefully adjusted and holds the sighting target in place. In other words, the targets are merely suspended on springs connected to the ends of the metal mounts, but they are really interconnected by this wire of invar so that any expansion or contraction in the metal tube will not affect the 2-meter distance at which the two targets are placed.

MR. HANNA (California): I operate in a rural area and I have been very interested in this thing. I have never used it, but I am waiting for an instrument that will span the gullies in my county, some of those that are 1,500 feet deep and three-quarters of a mile across.

[1] *See* "A Study of the Use of the Wild Telemeter DM 1 for a Closed Traverse," by Robert D. Turpin, SURVEYING AND MAPPING, October–December 1954.

MR. TANNER: Maybe one of those Texas bars would help.

MR. BERRY: I got a little worried about the accuracy that could be obtained. Never mind trying one. That isn't the way we do it. We sit down with papers. So we sat up all night with the calculus, and finally came up with a rather interesting relationship. On a single distance now, not a full length of a traverse, the accuracy of the distance derived is directly proportional to the error with which you can read the angle compared to the total value of the angle itself. In other words, if you expect 1 in 5,000 accuracy, and you can read the angle, using this very fine instrument, with an error not to exceed 1 second, then you have to have at least 5,000 seconds in the subtended angle in order to get 1 in 5,000 accuracy. If there are not 5,000 seconds there and the error is 1 second, you cannot get 1 in 5,000 accuracy because there are not 5,000 units there to measure. That can be deduced intuitively, but the calculus seems to bear us out, and I don't quite agree with Mr. Tanner's figures. Maybe we had better check back and forth, but I came up with the fact that, if you want 1 in 5,000 accuracy, the horizontal distance couldn't be greater than 267 feet because that is the distance subtended by 5,000 seconds on a 2-meter bar. One of the gentlemen asked about other bars. All this is directly proportional to the length of the bar, and I have used, personally, a 3-meter subtense bar made by Zeiss. If anybody wants to argue the matter with me, I have a few copies here.

CHAIRMAN GHENT: Anything you want to say in rebuttal, Mr. Tanner?

MR. TANNER: No, thank you. We will compare notes afterwards, Mr. Berry and I.

CHAIRMAN GHENT: We want to thank you, Mr. Tanner, for your fine presentation to this group.

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A New Philosophy for Making Measurements

By SUMNER B. IRISH
PRINCETON UNIVERSITY

TO SAY that a new philosophy for making measurements is desirable or necessary is probably to raise a debatable point. The subject of how we should or should not make measurements has been discussed from time immemorial. In so doing, however, much has been forgotten so that it can be said, at least, that it is now time to reexamine our methods of making the basic surveying measurements.

Each and every day the thinking surveyor must come in contact with at least one measurement made by someone lacking a real appreciation of what takes place when a survey is made. Allow me to cite some examples of work that, to my mind, is in need of reevaluation.

NEED FOR APPRECIATION OF ACCURACIES

Recently, a detailed and carefully made survey was reported upon before a session of one of the technical societies. Among other things, the speaker reported how a base line was measured in connection with the triangulation work which was to ensue. Extreme care was used in making all the corrections that are related to base-line work. The reported probable error was 1/3,800,000, or, as I would express it, the unit error reported was $\pm 0.026 \times 10^{-5}$ foot/foot. How often do we get that kind of accuracy in our work? Not very often. But was that accuracy really there? I think not. The tape which was used was standardized by the National Bureau of Standards and reported to be 100.001 feet long at 10 pounds tension. That would mean, to me, that the actual length of the tape was somewhere between 100.0005 feet and 100.0015 feet at that tension or, in other words, the tape had a possible error of ± 0.0005 foot in 100 feet and an average error of ± 0.00025 foot in 100 feet, or an average unit error of $\pm 0.25 \times 10^{-5}$ foot/foot. This is almost 10 times the error reported. What happened in this case is not unusual. It represents a lack of appreciation for the fact that every piece of equipment and every technique which we use and every measurement which we make involves some sort of an error that needs evaluation.

Another recent project report told of another base line that measured with extreme care six different times by making three round trips back and forth. Results were excellent, but the accuracy obtained from three round trips was only slightly better than that from one round trip. Again, a true appreciation of what was being done was not present. This was on an engineering job where man-hours very definitely meant dollars; but dollars seemed to mean nothing to these surveyors. Too often we are inclined to measure distances and angles with a degree of accuracy which reflects primarily a love for a fine job done well, almost as a work of art, rather than for an engineering job done to the required standards at the minimum cost.

Angle measurements suffer from the same trouble. It is very easy to set up at a station and to turn angles two, three, or six times, direct and reverse. I doubt, however, that on any but the most precise work angles need to be turned more than once direct and once reverse to produce the desired results. Again, the surveyor seems to be reflecting an unscientific approach to his work. He seems to be saying, "I will do this enough times so it is bound to be O. K."

Presented at the Fifteenth Annual Meeting of the American Congress on Surveying and Mapping, Washington, D. C., Mar. 9–11, 1955.

As for evaluation of his work, he seems to have done precious little of it.

A final example which I would like to mention and which shows a poor appreciation of accuracies in surveying work involves a graduate student who wanted a contour map of the Princeton area at about twice the scale of the available quadrangle sheet. This was gotten very easily by an enlargement of the pertinent topographic sheet. However, on the enlargement, the 20-foot contours were too far apart in his judgment. He was, therefore, going to interpolate with an intermediate line and make a 10-foot contour map out of the enlargement. I questioned the wisdom of doing this and tried to show him that not too much good would come of it. He felt, however, that he would, by drawing in these additional contour lines, have more information as to the grades on the streets, and so forth. I would hesitate to guess the accuracy of the resulting contour map.

In the examples shown above, we can say that good, straightforward engineering thinking was not present. Analysis, a fundamental aspect of engineering, was not followed in those projects. Yet it is absolutely necessary for us to do just that if surveying is to survive as a part of engineering. While we want surveys that are satisfactory, we want them satisfactory as engineering jobs and not as works of art. We must get away from that old idea of surveying as an art and make a science of it. We must find out what will put it on sounder ground and proceed to do just that. Developing a fundamental scientific approach to making measurements is one, but only one, very important aspect of the work.

Upon looking over the more common surveying texts and references, I see no end of the necessary beginnings for the type of analysis which I am advocating; however, in all cases the surface is merely scratched. The formulas are given for the corrections to tape lengths, for instance, but no attempt is made to follow through and to measure the effect of the errors in the determination of the various factors in the formulas. The textbook which best handles what I am discussing is *Surveying*, 4th edition, by R. E. Davis and F. S. Foote. The authors do organize in somewhat of a systematic form the corrections which must be considered when making the basic measurements with the tape, the transit, and the level. They do lay down specifications for achieving certain accuracies, but these are only the very crudest. Yet they will guarantee satisfactory results with an ample margin to spare.

There is a definite challenge to go ahead and to do some constructive work on this subject. We must try to establish criteria for measurements than can be used intelligently for the design of surveys. Surveys will then reflect an engineering approach and analysis which are so desirable in our work.

EXPRESSING THE MAGNITUDE OF ERRORS

Before analyzing the errors in our measurements, I would like to discuss briefly the method of expressing the magnitude of errors. In the past, this has been done by using the relative-fraction idea of 1 over a number which is so common and useful on the maps we make. This concept very definitely has its shortcomings, however, in dealing with errors. Often the square of the errors from the various components of a distance or an angle have to be added together. When they are expressed as relative fractions it is not a simple operation. In place of the relative-fraction concept I recommend that we define the errors in taping in each case as so many parts per hundred thousand or some other power of ten. For example, a distance which has an accuracy as now expressed of 1/25,000, would, in the recommended system, be expressed as $\pm 4 \times 10^{-5}$.

TAPING ERRORS

Now, let us take a more critical look at some of the errors in taping, how they occur and their magnitude. Let us see if a new and sounder philosophy for making measurements can be developed, and particularly in line with the recommended method for defining errors.

Errors in Tape Length

The first error in taping which should be considered is that due to the tape itself—an instrumental error. If the tape is standardized by the National Bureau of Standards, the length will probably be given, as mentioned previously, to the nearest 0.001 foot in 100 feet. This permits a maximum error of ± 0.0005 foot in the 100 feet of the tape or an average or probable error of ± 0.00025 foot in 100 feet. A unit probable error in distance of $v_1 = \pm 0.25 \times 10^{-5}$ foot/foot will result; this must be considered when determining the overall accuracy of distance measurements. If means other than the National Bureau of Standards are used in standardizing the tape, the limitations of that method must be similarly considered.

Correction for Temperature

The second error is that resulting from the determination of the correction for temperature. The basic formula is included in all surveying texts and is readily evaluated by any student or surveyor. However, the accuracy of the correction depends just as much on the accuracy of the temperature determination as it does on the correct arithmetical manipulation of the numbers involved. Let us look at the accuracy of that determination, and its consequent effect on the accuracy of the distance measurement.

Let

L = total measured length, feet
t = final temperature, degrees Fahrenheit
t_o = original temperature, degrees Fahrenheit
C_f = correction to length L due to temperature difference, feet
e_f = unit correction due to temperature difference, feet/foot
Δt = probable error in temperature measurement, degrees Fahrenheit
v_2 = unit probable error in distance due to error in temperature measurement, feet/foot.

Then

$$C_f = 0.00000645\ L\ (t - t_o)$$
$$e_f = 0.00000645\ (t - t_o)$$
$$v_2 = 0.00000645\ \Delta t.$$

By establishing the accuracy to which the temperature can reasonably be determined, the accuracy of the correction due to the temperature can then be stated. This correction will be another step on the way toward determining the accuracy of the distance measured.

The converse reasoning can also be used in this case. With a certain limit established for the unit probable error in distance due to the error in temperature determination, the accuracy with which the temperature must be measured can then be specified. The evaluation of the necessary relationships is facilitated by a graph, figure 1.

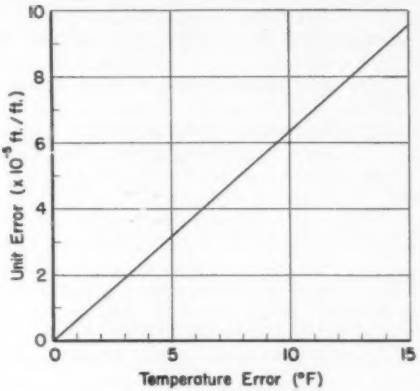

FIGURE 1.—Unit error in distance due to error in temperature measurement.

Error in Vertical Alignment

The next error which will be considered is that due to vertical alignment. This is very much of a problem, particularly to those who use the tape horizontally. That aspect will be considered first.

The correction for a deviation from the horizontal, better known as slope, is well known as it is one of the fundamental corrections to which we expose our students. This expression is the basis for evaluating the unit probable error in distance due to an error in vertical alignment.

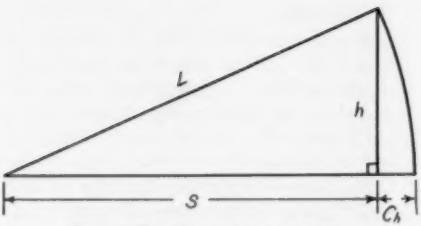

FIGURE 2.—Correction for slope.

In figure 2, let

h = difference in elevation of ends of tape, feet

C_h = correction to length L due to slope of tape, feet

e_h = unit correction due to slope of tape, feet/foot

v_3 = unit probable error in distance due to error in vertical alignment, feet/foot.

Then

$$C_h = \frac{h^2}{2L} - \frac{1}{8}\left(\frac{h^4}{L^3}\right) + \frac{3}{16}\left(\frac{h^6}{L^5}\right)$$

$$v_3 = e_h = \frac{1}{2}\left(\frac{h}{L}\right)^2 - \frac{1}{8}\left(\frac{h}{L}\right)^4 + \frac{3}{16}\left(\frac{h}{L}\right)^6.$$

Again, knowing the overall length of the tape, or the segment to be used, the unit probable error in the distance due to an error in the vertical alignment of the tape can be predicted. Or the converse can be stated, that is, with a certain limit on the unit error, the ends of the tape must be held horizontal within certain specified limits. A graph is shown (fig. 3) which simplifies the computations of the pertinent values.

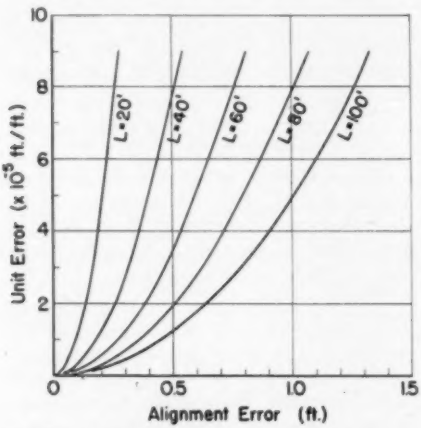

FIGURE 3.—Unit error in distance due to error in horizontal and vertical alignment.

For the case in which the tape is used on a slope, determination of the unit error in distance due to the error in the determination of the difference in elevation of the ends of the tape will also be made from the slope-correction formula.

Where

Δh = probable error in difference in elevation, feet

v_4 = unit probable error in distance due to error in difference in elevation, feet/foot.

Then

$$C_h = \frac{h^2}{2L} - \frac{1}{8}\left(\frac{h^4}{L^3}\right) + \left(\frac{3}{16}\right)\frac{h^6}{L^5}$$

$$e_h = \frac{1}{2}\left(\frac{h}{L}\right)^2 - \frac{1}{8}\left(\frac{h}{L}\right)^4 + \frac{3}{16}\left(\frac{h}{L}\right)^6$$

$$v_4 = \frac{h\Delta h}{L^2} - \frac{1}{2}\left(\frac{h^3\Delta h}{L^4}\right) + \frac{9}{8}\left(\frac{h^5\Delta h}{L^6}\right).$$

A graph for a tape length of 100 feet is included (fig. 4) to facilitate the determination of the unit probable error. It is used in a manner similar to the foregoing graphs. Knowing the measured difference in elevation of the ends of the tape and the

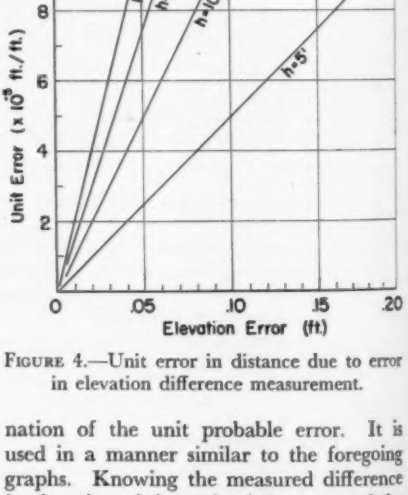

FIGURE 4.—Unit error in distance due to error in elevation difference measurement.

error in that determination, the unit probable error in the distance can be evaluated. Or, knowing the allowable unit probable error in the distance, and the difference in elevation of the ends of the tape, the permissible probable error in that elevation difference determination can be evaluated.

Error in Horizontal Alignment

The problem due to an error in the horizontal alignment is very similar to that for vertical alignment. The same equation holds; however, the resulting unit probable error, as a rule, is generally much smaller than that found in the vertical alignment problem. The surveyor much more readily finds clues to help him in maintaining good horizontal alignment than he does for vertical alignment. Nevertheless this error does need to be considered.

Let

C_a = correction to length L due to misalignment of tape, feet
a = net error in horizontal alignment of ends of tape, feet
e_a = unit correction due to misalignment of tape, feet/foot
v_5 = unit probable error in distance due to error in horizontal alignment, feet/foot.

Then

$$C_a = \frac{a^2}{2L} - \frac{1}{8}\left(\frac{a^4}{L^3}\right) + \frac{3}{16}\left(\frac{a^6}{L^5}\right)$$

$$v_5 = e_a = \frac{1}{2}\left(\frac{a}{L}\right)^2 - \frac{1}{8}\left(\frac{a}{L}\right)^4 + \frac{3}{16}\left(\frac{a}{L}\right)^6.$$

The graph (fig. 3) used to evaluate the unit probable error due to an error in vertical alignment can also be used to facilitate the computation of the unit probable error due to an error in horizontal alignment. As before, either the unit probable error can be determined assuming a limit on the alignment error, or a limit on the alignment error can be determined assuming a limit on the unit probable error in distance.

Variation in Tension

Two types of errors are introduced in taping due to the variation in the tension on the tape. The first appears through a change in the elongation of the tape as determined by a consideration of Hooke's Law, and the second by a consideration of the sag correction. Obviously one cannot hold a tape exactly at a specified tension, and it is necessary to evaluate the effect of any variation.

The error caused by a change in elongation through a consideration of Hooke's Law will be considered first.

Let

P = final tension, pounds
P_o = original tension, pounds
A = cross-sectional area of tape, square inches
E = modulus of elasticity, pounds/square inch
w = weight of tape, pounds/foot
C_p = correction of length L due to a change in tension and according to Hooke's Law, feet/foot
e_p = unit correction due to change in tension and according to Hooke's Law, feet/foot
ΔP = probable error in tension determination, pounds
v_6 = unit probable error in distance due to error in tension elongation and according to Hooke's Law, feet/foot.

Then

$$C_p = \frac{(P - P_o)L}{AE}$$

$$e_p = \frac{P - P_o}{AE}$$

$$v_6 = \frac{\Delta P}{AE}.$$

Where $A = \dfrac{w \times 144}{490}$ square inches, and $E = 29 \times 10^6$ pounds/square inch

$$v_6 = \frac{0.01173 \times 10^{-5}\,\Delta P}{w}.$$

For any weight tape, if the accuracy with which the tension can be exerted is known, the unit probable error in distance according to Hooke's Law can be determined. Conversely, for specified limits on this phase of the unit errors in distance, a limit on the variation of the tension pull can be established for any weight tape. Again a graph

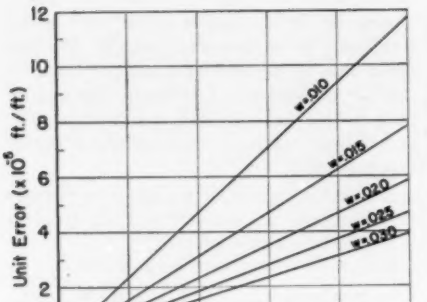

FIGURE 5.—Unit error in distance due to error in tension (elongation).

(fig. 5) is furnished to facilitate the evaluation of the proposed equation.

The error caused by a change in length resulting from the variation of the tension as it affects the sag correction will next be considered. The familiar formula for the sag of a tape considering its shape as a parabola will be used, rather than the more complicated and only slightly more precise formula considering it in its true shape as a catenary.

Let

C_s = correction to length L according to the sag formula, feet

e_s = unit correction according to the sag formula, feet/foot

v_T = unit probable error in distance due to the error in tension elongation and according to the sag formula, feet/foot.

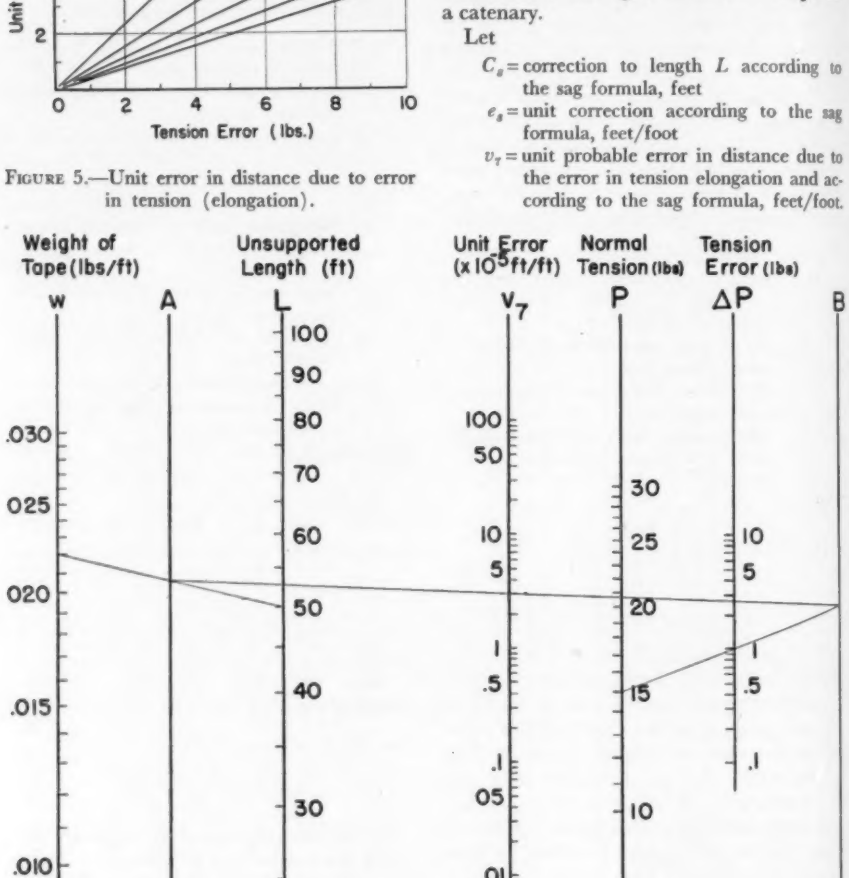

FIGURE 6.—Unit error in distance due to error in tension (sag).

Then

$$C_s = \frac{w^2L^3}{24P^2}$$

$$e_s = \frac{w^2L^2}{24P^2}$$

$$v_T = \frac{w^2L^2\Delta P}{12P^3}.$$

Through the above formula, the unit probable error in a distance according to the sag formula can be determined for a variation of the tension from some accepted normal value. To assist in the use of the formula, and to provide a ready means for evaluating it, a nomograph (fig. 6) is included which will handle the usual ranges and weights of tapes, tensions, and unsupported lengths.

A sample problem is worked out on the nomograph to show its use. Assume that a tape weighs 0.022 pound per foot and is used with a normal tension of 15 pounds. For an unsupported length of 50 feet, and a probable error in the tension of 1 pound, what will be the unit probable error in the taping due to a consideration of sag only? To solve this problem, enter the "w" line with the weight of the tape, 0.022 pound/foot. Simultaneously, enter the "L" line with the unsupported length, 50 feet. Determine where the line connecting those two points intersects the "A" line. Next enter the "P" line with the normal tension, 15 pounds, and simultaneously enter the "ΔP" line with the probable error in the tension, 1 pound. Determine the point at which the extended line connecting the last two points intersects the "B" line. Connect the points on the "A" and "B" lines. Where this line intersects the "v_T" line, the answer to the problem, 3.0×10^{-5} foot/foot, will be found.

Elevation Above the Datum Plane

A final correction which it would be well to look at analytically is that due to elevation above the datum plane. This is a minor correction in most cases, but there are many places where a recognition of this should be made. This is particularly true if results are to be referred at a later date to distances in a State plane coordinate system, to mean sea level, or to some similar basis.

In figure 7, let

R = average radius of the earth, feet
d = distance above the datum plane, feet
C_d = correction to length L due to distance above datum plane, feet
e_d = unit correction due to distance above the datum plane, feet/foot
Δd = probable error in elevation determination, feet
v_s = unit probable error in distance due to error in elevation above datum plane, feet/foot.

Then

$$\frac{L - C_d}{L} = \frac{R}{R + d}$$

$$C_d = \frac{Ld}{R - d}$$

$$e_d = \frac{d}{R - d}$$

$$v_s = \frac{\Delta d}{R} \text{ (very nearly)}.$$

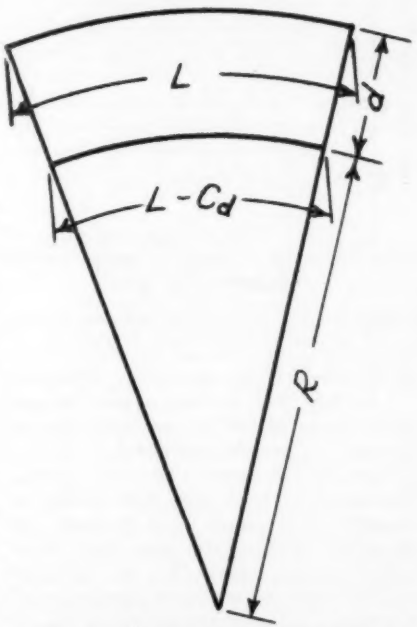

FIGURE 7.—Correction for vertical datum.

Where

$$R = 20.93 \times 10^6 \text{ feet}$$
$$v_6 = 0.00478 \times 10^{-6} \Delta d.$$

The evaluation of the formula is very simple. Limits can very easily be set on the unit probable error due to the error in the elevation above the datum plane. The accuracy necessary for the mean elevation above sea level can then be stated. Although the tolerances in this error are wide, it does not eliminate the fact that this correction must be considered if good taping is to be done. A graph (fig. 8) is included to provide easy computation of this error.

Combinations of Taping Errors

The foregoing represents a rather comprehensive analysis of the errors involved in the various aspects of the taping operation

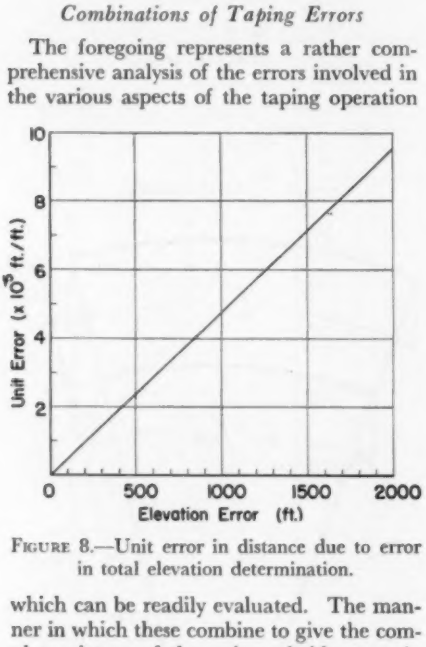

FIGURE 8.—Unit error in distance due to error in total elevation determination.

which can be readily evaluated. The manner in which these combine to give the complete picture of the unit probable error in distance will now be considered.

Two of the errors, that from vertical alignment, v_3, and that from horizontal alignment, v_5, always tend to make the measured distance too long and consequently have one sign only. All the others tend to make the measured distance either too long or too short and strictly by chance. Therefore, the last-mentioned group will be considered as positive or negative, inasmuch as the laws of chance hold, and the final probable error for that group will be the square root of the sum of the squares of the individual probable errors. With this in mind, the final unit probable error in distance for taping which may be readily analyzed may then be defined as follows:

$$V = \sqrt{v_1^2 + v_2^2 + v_4^2 + v_6^2 + v_7^2 + v_8^2} + v_3 + v_5.$$

The sign of the radical is chosen so as to agree with the sign of the alignment errors. In this manner the worst situation, from a statistical standpoint, is evaluated. This is necessarily on the conservative side.

Other Sources of Error

While the above errors include most of those which occur in taping, there are a few more which should be mentioned, one way or another, and suggestions should be made as to how they should be handled.

Reading the graduations on a tape may be subject to some error. For precise work, a scratchawl is used to make a mark on a copper plate at the front end of the tape. The rear end of the tape is then brought abreast of this fine line. It is doubtful if a probable error of more than ± 0.0005 foot exists in each tape length due to this cause. For a 100-foot tape this gives a unit probable error of $\pm 0.5 \times 10^{-5}$ foot/foot. If a plumb-bob string is held across the tape, a guess of the probable error encountered would be something like ± 0.0015 foot at each end of the tape. Considering the two ends of the tape and that the laws of chance apply, the probable error would be approximately ± 0.0021 foot, or a unit probable error of $\pm 2.1 \times 10^{-5}$ foot/foot for a 100-foot tape.

The foregoing figures are only guesses. They nevertheless reflect ignorance which needs enlightenment. This is one point which needs investigation.

Another source of error worth investigation, regarding whose magnitude the writer would not want to hazard even the roughest guess, is that which occurs when marking the ends of the tape on the ground when the tape is used horizontally and supported

at both ends. The swing of the plumb bob is something that defies analysis at a desk, but it can be determined successfully and accurately by the analysis of field data. Different weights of plumb bobs, lengths of free strings, wind velocities, and operators will need to be taken into account. This error is undoubtedly one of the principal errors in the taping process. It probably reduces to insignificance most of the errors previously mentioned. That is all the more reason why this error should present a challenge to the surveying teacher to investigate and systematize the knowledge of this phenomena.

Wind is the last factor affecting the taping operation to be considered. Its action is very much akin to that of the weight of the tape which produced sag. Whether or not it can be analyzed satisfactorily is a debatable point. Probably some investigation of this source of error should be made, but how the information might be used, the writer is not certain. Unquestionably, precise taping operations should not be undertaken in a strong wind. Perhaps that is what needs to be said about this error.

Thus the story for taping is concluded. As stated at the very beginning, the relationships established are not new but merely restated. They represent the desirable analytical approach to taping. And with it we have a sound philosophy for making measurements.

Applying the above error theory, the surveyor who is measuring a distance will know what he is doing and what he should get as a result. He will know how careful he has to be when measuring temperature, slope, tension, and so forth. It is unquestionably the correct approach for making measurements.

ERRORS IN ANGLE MEASUREMENT

Types of surveying measurements other than taping will lend themselves to similar analysis for an ultimate benefit to the work which the surveyor does. Take the measurement of angles with the engineer's transit or optical-reading theodolite. Through preliminary investigations, the writer has found that the experimental approach promises to play a larger role in the determination of errors encountered in angle measurements than in taping measurements. Some mathematical analysis can be made, but it seems to be limited. The writer hopes to have some information on certain aspects of this work in the near future.

ERRORS IN LEVELING

Leveling presents a challenge for more scientific handling also. This is in accord with the recommended philosophy of making measurements. An intelligent analysis of the quantity and quality of work which a level is capable of producing is, of course, an absolute "must" for a sound approach to leveling. The writer, with Prof. Philip Kissam, has developed the Princeton Level Test, which is a means of measuring the standard angular error, σ_u, of a level. The standard angular error combines most of the errors of leveling due to the instrument itself, such as parallax, atmospheric refraction, variation in temperature, settlement of the tripod bubble not centered at the instant of sighting, and inability of the observer to read the rod easily. This error in the instrument can be related to the error per mile which the instrument will produce through the following formula:

$$e = 72.7\, C \sqrt{l}\, \sigma_u$$

where

e = error per mile, feet
C = factor dependent upon percent of level lines to be satisfactory
l = length of sight used, feet
σ_u = standard angular error of level, radians.

This formula has been set up in a nomograph (fig. 9), which follows, for easy solution.

The work on levels mentioned above says nothing about the rods used in leveling although they are vitally important to the quality of work done. In particular, nothing is said about the rod not being of standard length and not being held plumb, nor anything about the expansion and contraction of the rod, or the settlement of turning points. In order to have the complete story on leveling, this information should be on

hand. It should not be too difficult to obtain. Then, the complete analysis of leveling can be made exactly as the complete analysis of taping is carried out.

INSTRUMENTAL ERRORS

Instrumental errors need investigation very badly. All surveying texts give procedures for making the adjustments to the instruments, but none say specifically what is the effect of the instrument being out of adjustment. How accurately must the adjustments be made for acceptable surveys? Statements can and probably will be made in a qualitative sense, but we need to bring out into the open information regarding the importance of adjustments in a quantitative sense. For example, when perpendicularity of the line of sight to the horizontal axis of the transit is tested, what is the overall effect of an error of 0.002 foot at 100 feet at the end of the test? Do we really need to adjust the transit in that case? Or had we better leave well enough alone? What is the answer and why?

Optical distance-measuring devices are providing a very fruitful field for this type of analysis. These instruments are popular in Europe, but, as yet, not so here. What quality of work can be done with them? Should we give consideration to them?

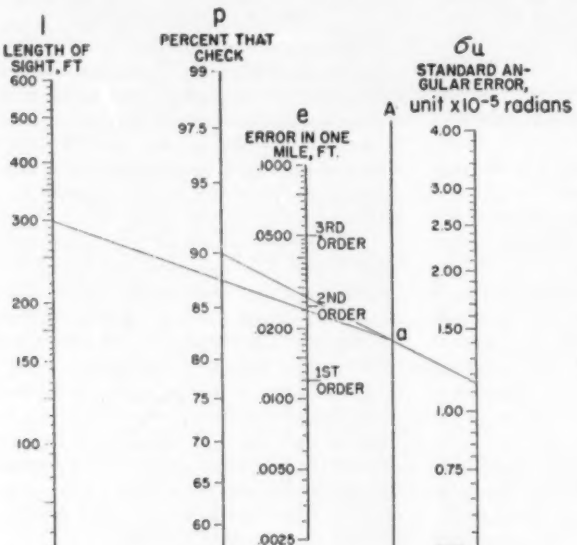

FIGURE 9.—Error per mile in leveling.

Evaluation of the optical distance-measuring devices requires a combination of the techniques for the analysis of taping and those for the analysis of angle measurements. This needs to be done and needs to be publicized. Prejudice and tradition must not prevail over technical superiority.

Finally, the accuracy of the basic tools of surveying can be considered together in making an analysis of the techniques calling on one or more of these tools. Traverses and triangulation nets specifically warrant investigation. Traverses are an everyday occurrence in the life of many surveyors, and the errors possible in them should be understood. What are the contributions of angle and distance accuracies to the accuracy of a traverse? These should be known.

A SOUND APPROACH TO MEASUREMENT

The latter part of this paper has posed many more questions than it has answered. That probably is not the customary function for this type of paper. However, the writer feels that it is a necessary feature in his effort to transmit an idea of what we must do to have a sound approach to making measurements.

I trust that, in a small measure, the first portion of this paper will perhaps be useful

with its analysis of taping with concrete suggestions as to how the new philosophy can be accomplished; and it is important that we use this philosophy for making measurements. We must use good analytical techniques in what we do. Thus, and only thus, will surveying progress and survive.

* * *

Federal Cartographic Records in the National Archives

By CHARLOTTE M. ASHBY

THE NATIONAL ARCHIVES

THE NATIONAL ARCHIVES, established in 1934, is the official depository for all records of enduring value accumulated by the United States Government and is responsible for making such records available to Government officials, scholars, and other interested persons. In 1949 the National Archives was transferred to the newly created General Services Administration, where it became a division of the National Archives and Records Service.

Among the records in the National Archives are a great many maps that have been filed by Government agencies. Some of the maps are so closely related to textual records that they are kept with those records. Most of them, however, have been physically separated from other records and are kept together in a map collection.

In this collection are over 800,000 maps and related cartographic records of enduring value, received from 125 different Government agencies. Approximately 500,000 of the maps are in manuscript or are annotated and are believed to be unique. These cartographic records cover a wide variety of subjects and areas, although most of them relate to the United States, its parts, and possessions.

In the National Archives, cartographic records are not arranged by area as in most map depositories. According to archival practice, all records—textual, pictorial, and cartographic—are grouped by agency of origin, in numbered and titled record groups, *e.g.*, Record Group 37, Records of the Hydrographic Office; Record Group 49, Records of the Bureau of Land Management; and Record Group 77, Records of the Office of the Chief of Engineers. The National Archives has issued many preliminary inventories of record groups, some including maps which are briefly described by series. For larger and more specialized cartographic records, however, detailed descriptions are desirable to familiarize scholars and others with the National Archives' map holdings.

Because of the urgent need for office space by Government agencies during the period 1940 to 1946, the National Archives accepted large quantities of unscreened and poorly arranged records. The staff of the Cartographic Records Branch was occupied for some time, therefore, in screening nonrecord and duplicate materials among its holdings and rearranging pertinent records into logical subgroups and series according to origin. This task has now been completed.

To forestall such disorganized dumping of records in the future, a records schedule has been adopted that controls the authorized disposition of all cartographic records wherever created and existing in the Federal Government.[1] Hereafter cartographic records received by the National Archives from

[1] General Records Schedule 17, Cartographic, Photogrammetric, and Related Records, approved by Congress August 9, 1954, and published as Ho. Rept. 2644, 83d Cong., 2d Sess.

Government agencies should be free of nonrecord and duplicate materials and arranged in accordance with a prescribed or otherwise acceptable order. Transfer will thus be selective and controlled rather than haphazard.

The arrangement of cartographic records by organized groups has made it possible for the staff of the Cartographic Records Branch to prepare descriptions of the records. Since 1952, five publications describing cartographic record groups have been issued. These are available on request to the National Archives, Washington 25, D. C. They are:

Special List No. 13, "List of Cartographic Records of the Bureau of Indian Affairs" (1954, 127 pp.), by Laura E. Kelsay.

Preliminary Inventory No. 45, "Cartographic Records of the Federal Housing Administration" (1952, 57 pp.), by Charlotte M. Ashby.

Preliminary Inventory No. 68, "Cartographic Records of the American Commission to Negotiate Peace" (1954, 11 pp.), by James B. Rhoads.

Preliminary Inventory No. 73, "Cartographic Records of the United States Marine Corps" (1954, 17 pp.), by Charlotte M. Ashby.

Preliminary Inventory No. 81, "Cartographic Records of the Office of the Secretary of the Interior" (1955, 11 pp.), by Laura E. Kelsay.

Other inventories and lists recently completed and scheduled for publication in 1955 include cartographic records of:

The Panama Canal
The Office of the Chief of Naval Operations
The National Recovery Administration
The Office of the Chief of Engineers
The Soil Conservation Service
The Railroad Division of the Reconstruction Finance Corporation
The Hydrographic Office

Concurrently with the preparation of inventories and lists of the records by individual record groups the staff is compiling a comprehensive guide to the cartographic records in the National Archives. This guide will be in two sections. The first will include descriptions of records by group and subgroup. The second will be a detailed index to the subject content of the maps. The latter will be especially useful in that it will facilitate the area approach to records that most searchers prefer to use. The incomplete index is already proving invaluable to the staff in answering reference questions that relate to subjects and areas.

❦ ❦ ❦

Gurley Announces New Equipment

A modern lightweight range pole has been introduced by W. & L. E. Gurley, Troy, N. Y. The new Gurley range pole is formed from lightweight metal tubing and has a steel point at one end, which provides excellent balance for plumbing.

Eight-foot poles are made in two sections. The sections are joined by means of a slip-joint which provides the added feature that wear can be taken up by simply spreading the split-plug connector. No special tools are needed. A hand axe or a jackknife can be inserted in the slots to spread the metal, thus tightening the joint.

The top section of this pole has a plug which can be removed to permit the addition of an extra four-foot section.

A new "Standout Bubble" has been added to all Gurley transits and levels. This enables the leveling of these instruments to be accomplished more easily under adverse light conditions.

The ends of the glass vial containing the bubble have been tinted black. This black surface causes the ends of the bubble to appear to have been darkened and makes the position of the bubble ends more clearly visible.

For further information concerning either of the above items, write to W. & L. E. Gurley, 530 Fulton St., Troy, N. Y.

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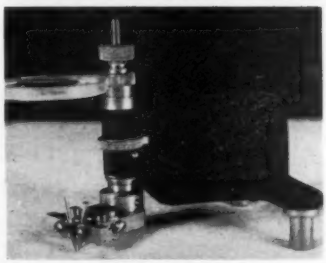

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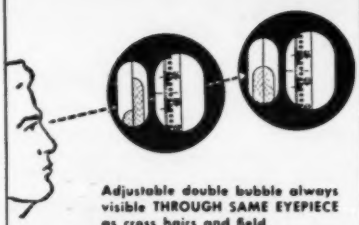

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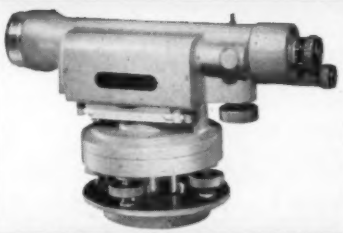

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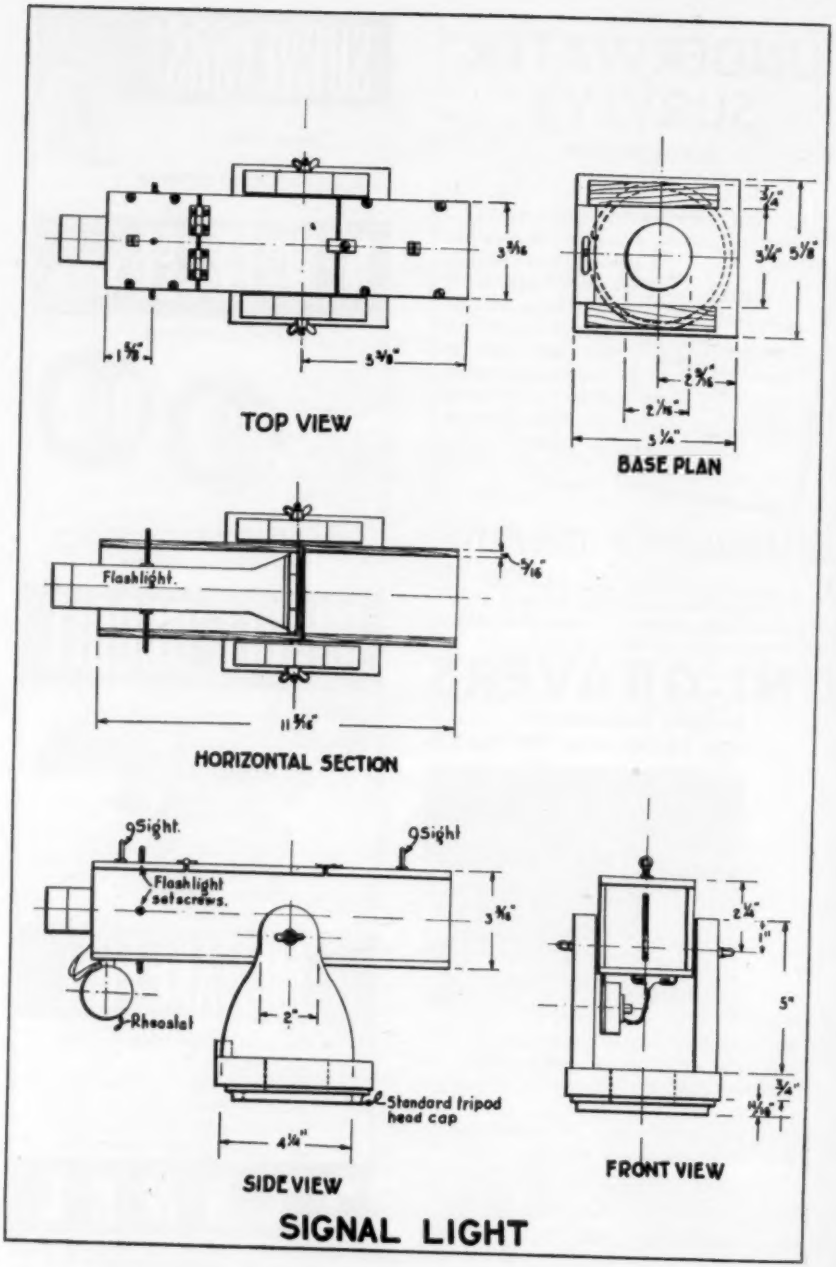
3 5/16
1 5/8"
3 5/8"
TOP VIEW
3/4"
3 1/4"
5 1/8"
2 3/16"
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5 1/4"
BASE PLAN
Flashlight.
5/16"
11 5/16"
HORIZONTAL SECTION
Sight.
Sight
Flashlight set screws.
3 3/8"
Rheostat
2"
Standard tripod head cap
4 1/4"
SIDE VIEW
2 3/4"
1"
5"
3/4"
1 13/16"
FRONT VIEW
SIGNAL LIGHT

Triangulation and Traverse Signal Light

By HENRY L. THOMSON

DEPARTMENT OF PUBLIC WORKS, CITY OF LOS ANGELES

OBSERVATIONS for triangulation when made at night using signal lights generally give results superior to those obtained in daytime observations.

A reliable signal light which can be accurately pointed, has a good light pattern and a range in size and intensity of light, is essential for satisfactory night observations. The signal light described below has been developed during the last fifteen years to meet the requirements of metropolitan first-order triangulation and traverse surveys.

The body of the light, which is made much like a transit in principle, consists of a base, standards, and light box. It is usually mounted on an extension-leg tripod. The body can be turned on the tripod head and the box tilted for pointing.

The light source finally adopted because of its fairly uniform light pattern and stability of adjustment is a two-cell flashlight with a bakelite case and a fixed-focus bulb with shatterproof glass window in front. The reflector is coated with rhodium which does not oxidize or become dull. An extra bulb is carried in the rear screw plug. The whole assembly is waterproof. This flashlight, called the Tuffite F-80, is made by the S. R. Browne Manufacturing Company, Inc., 258 Broadway, New York 7, N. Y.

The beam of the flashlight must be alined with the survey line by means of the screw-eye sights. This adjustment can best be made in a long, darkened basement or outside at night. The rear of the flashlight case is moved by the four adjusting screws in the rear of the box so that the bright part of the light pattern appearing on a wall, from 50 to 100 feet away, will be seen through the screw-eye sights.

The brightness of the light is controlled by a 15-ohm rheostat, mounted at the rear of the box. Current is supplied, through a flexible cord, from two No. 6 dry cells connected in series.

The diaphragms or stops are made of 1/64-inch pressboard, with rectangular vertical slots from 1/32- to ½-inch wide. These are kept in the light box. Any one of these can be inserted in the slot in front of the flashlight. The diaphragm can be quickly removed, giving a wide-open light for identification or signaling. In triangulation, the observer directs the lightkeeper by signals or radiophone until he obtains a light of suitable size and brightness for the best observations.

On first-order traverse, the signal lights are mounted on tripods 8 to 15 feet high to get above obstructions and minimize refraction. The long tripod legs are wooden curtain rods of the proper size to fit the extension-leg tripods.

In order to insure accuracy with the relatively short sights between traverse monuments in a city, the center of the narrow light slot must be set as closely as possible over the station point. This is done with a transit set on line, 15 to 20 feet ahead of the light. The light box is moved laterally until the crosshair bisects the lighted slot. The pointing of the light on the theodolite is checked by sighting through the screw eyes.

These signal lights have a wide field of usefulness, being often used for the accurate establishment of long transit lines in the daytime when visibility is poor.

1956 ACSM-ASP CONSECUTIVE MEETINGS AND CO-EXHIBIT
March 19–24, 1956, Washington, D. C.

The Repair of Instruments, and the Relationship of the Instrument Repairman to the Surveyor

By LAWRENCE R. SMITH and CLIFFORD A. THORPE, JR.

THORPE-SMITH, INC., FALLS CHURCH, VA.

I AM SURE that during the years in which you have practiced the profession of surveying, you have read many papers and booklets dealing with the care of engineering and surveying instruments. It is not the purpose of this paper and demonstration to criticize or to add unduly to what has been written by experts in different lines of engineering and surveying work. It is intended to show that the surveyor should learn to discriminate between the adjustments and repairs which he can do himself, and those which he should not attempt. Damage can be done by neglecting to make repairs, and it can also be done by a man in the field attempting to perform an operation that requires both special and proper equipment.

Because of the exceptional and varied rough treatment that the instrument is put to during a normal day's work, the instrumentman must use every precaution to avoid hitting or dropping his instrument. During my years of repairing, I have found that it is these two causes which lead to costly repairs.

Plain common sense is the safest guide in the handling of surveying instruments.

First, I would like to ask you a question, "What is the relationship of a repairman, or a firm engaged in performing expert repair work, to the engineer?" It is my opinion that such a firm or person is duty bound by the same code of business and professional ethics as the engineering and surveying profession. I sincerely believe the following points are included:

1. He must be qualified to perform repair work, and his ability must be recognized by the various manufacturers of instruments.
2. He must give an honest and accurate estimate of all repairs to be done.
3. He must give service to all and perform his work in the shortest time commensurate with good workmanship.
4. He must guarantee his work and uphold that guarantee.

Just as good, medium, and incompetent workmen are found in any type of business or profession, so are they found among those engaged in doing instrument repair work. I like to place repairmen in the following three classes. First, the *qualified repairman*—this man usually is a college graduate in engineering who is qualified through years of training and experience to perform repairs to instruments. He makes many of the parts needed and does a complete and thorough job. It is this type of man that the manufacturer will recognize as being able to make the instrument function as it was manufactured to do. Second might be called the *replacement repairman.* This man cannot do much more than order new every part that requires work to be done on it. He will tie up an instrument for a long period of time, and his charges are higher than necessary. The third and last is the worst of all. I call him the *cleaning and adjusting* man, but in truth he does neither of these necessary operations. This type of repairman has ruined more good instruments than I would care to mention. I think that many of you have met this type. He will wipe off an instrument, but beyond that his repair work follows the style of a blacksmith. The instrument is tightened, forced, shimmed up with paper, and it will not perform as it was built to do. Here you

Presented at the Fifteenth Annual Meeting, American Congress on Surveying and Mapping, Washington, D. C., Mar. 9–11, 1955.

will see low prices, so low in fact that you should be cautious from the very start.

The most frequent question that I am asked by engineers is, "When should an instrument that has not met with an accident or been dropped be sent in for repairs or for overhauling?" In answering this I will have to rule out the time element because no two surveyors or instrumentmen will take the same care of their equipment. An instrument should be repaired when:

1. It fails to perform within the prescribed closures of the work being done.
2. An engineer is having to waste valuable time on field adjustments and checks because he has lost confidence in the accuracy of his instrument.
3. The instrument starts to gum up and the screws are getting harder to turn and the verniers are becoming more difficult to line up and match.
4. Any of its moving parts bind or are stiff.

In order that you may determine if errors in work are attributable to the instrument, a conventional transit will be broken down and the points highlighted to show where an engineer or instrumentman may look for damage and wear which would cause an instrument to lose its accuracy. The following common causes of error in a transit will be discussed [EDITOR'S NOTE. —The points listed below were demonstrated with the aid of a transit partially disassembled for the purpose]:

1. Loose objective lens in mount or cell.
2. Canadian balsam between glass in objective lens starting to give way or deteriorate.
3. Cross hairs off perpendicular or out of adjustment.
4. Eyepiece lens loose.
5. Wear in telescope slide or bearings.
6. Wear in telescope axis bearing (out of round) or axis bent.
7. Lateral play in telescope axis—standard alignment.
8. Bent standards.
9. Bent upper spindle.
10. Wear in spindle causing it to ride shoulder.
11. Spindle not fitting, causing it to ride the taper.
12. Vertical play in spindle.
13. A and B vernier check.
14. Lower limb plate off center to spindle.
15. Check spindle centers, true to each after repairs.
16. Lower spindle—same as upper.
17. Wear or jump in upper- and lower-motion clamps.
18. Fit of clamps.
19. Bent plumb-bob hanger.
20. Play in tripod.
21. "Creeping" or defective plate or telescope vials.

The different designs of instruments, and the different types of mechanical means accomplishing the same function, make it impossible to explain them all within the alloted time. We do believe, however, that the brief explanations of these causes are of value to the engineer and surveyor.

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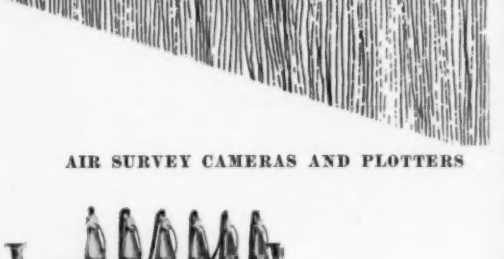

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Improving the Accuracy of Altimetry

By WARREN F. HARING

WALLACE & TIERNAN, INC., BELLEVILLE, N. J.

THE APPLICATION of engineering principles and methods is almost always closely related to economic considerations. There should be little wonder, therefore, that the time- and cost-saving features of altimetry using the atmosphere as a yardstick—and not requiring lines of sight—should continue to receive attention as a method which may permit greater accuracies. Furthermore, it is not surprising that efforts are being made to extend the permissible use of altimetry during times of more adverse weather conditions.

In the quest for higher accuracies and additional periods of use, we have two fields of action. One field is the perfection of a more sensitive and accurate altimeter as an instrument. This we will leave for the moment to the instrument engineer. The other field is the study of the vagaries of the yardstick—the atmosphere—to which this discussion will be confined.

THE YARDSTICK

It is hardly necessary to state that the air is seldom if ever in a state of equilibrium. However, we must establish some sort of pressure-versus-altitude relationship as a standard. The pressure-versus-altitude relationship as set forth in Smithsonian Meteorological Table 51 (fifth edition, revised, 1939 reprint) has been chosen as a standard because it is based upon the density of air at a *definite* temperature and humidity, namely, 50° F. and zero humidity. The use of this particular table is augmented by S. M. Table 52, which accurately sets forth the corrections that must be applied to the Smithsonian atmosphere for temperatures which may deviate from 50° F., and S. M. Table 54 for an average degree of humidity. By taking the average of air-temperature readings and an average value of humidity, additive corrections may be obtained from S. M. Tables 52 and 54. These corrections can then be added to the difference in altimeter readings and the sum divided by the difference in altimeter readings. The dividend resulting from this operation is the air-density correction factor. This air-density correction factor is then applied to the differences in all altimeter readings in this range. This assumes that the altimeters have been calibrated to a standard atmosphere (values shown in S. M. Table 51). Expressed as a simple equation, we have:

$$\begin{array}{lcll} \text{Difference in altimeter readings} & \times & \text{Air-density correction factor} & = \text{Standard air column to which altimeter is calibrated} \\ \text{Difference in altimeter readings} & \times & \text{Air-density correction factor} & = \text{Known difference in elevation} \end{array} \quad (1)$$

In this manner the altimeter scale is made to match more nearly the existing air-density conditions at the time of the field work.

Any analysis of the various factors which affect the accuracy of altimetry shows that the variation in air density is by far the most important single item. The relative accuracy of various field procedures has conclusively proven that a single base is the minimum requirement for the purpose of following the fluctuations of atmospheric pressure with time, and it has been standard practice to take air-temperature and humidity readings at various intervals near the ground. Anyone who has ever made a series of air-temperature and humidity readings has noticed that considerable differences exist within relatively short distances due to local radiation effects from the earth—incident energy from the sun, topographic features, geologic formations, and other causes. The first problem, therefore, has been one of making an accurate physical

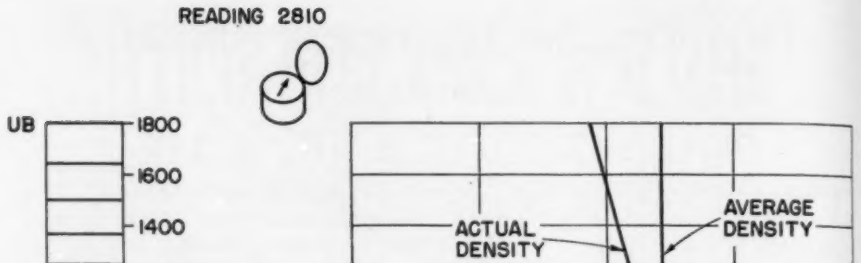

FIGURE 1.

determination of the *average* air density of the *entire* air mass or *vertical column* of air over the survey area.

Because changes in air temperature and humidity, individually and collectively, are reflected as changes in air density, and because the average density affects the total weight of the entire vertical column of air above any given point, there is no reason why the altimeter itself cannot be used to determine the air density. To see this most clearly, all we have to do is to transpose the terms in equation (1) above and observe that:

$$\text{Air density correction factor} = \frac{\text{Known difference in elevation}}{\text{Difference in Altimeter readings.}} \qquad (2)$$

By using altimeters in the evaluation of the right side of the equation, we can determine the air density more easily and more accurately than by using thermometers and psychrometers to evaluate the left side. Those who are familiar with the two-base method of altimetry will immediately recognize that this procedure is an inherent part of the two-base method.[1]

To illustrate the procedure for determining the air-density correction factor, consider two altimeters situated at base stations separated by a known vertical distance. (*See* figure 1.) The height is the difference in the known elevation of the upper base and that of the lower base. Let us assume the height to be 1,800 feet. If by some chance the altimeter readings at these bases differed by 1,800 feet, we would immediately deduce that the average air density was in accordance with the standard yardstick—namely, S. M. Table 51, to which the altimeter was calibrated—with 50° F. air temperature and zero humidity, making the air-density correction factor unity.

[1] *See* "Altimetry—Its Present-Day Techniques," by Lester E. Demler, SURVEYING AND MAPPING, July–September 1951.

It is more likely, however, that the difference in altimeter readings will be greater or less than the vertical distance between the bases by some amount—for example, 70 feet less. The amount by which the difference in altimeter readings, 1,730 feet, differs from the known difference in elevation of the two bases, 1,800 feet, is an index of the amount by which the average air density or weight of the intervening column has deviated from unity or standard conditions. The ratio of the difference in the known elevations to the difference in the altimeter readings gives the air-density correction factor to a higher order of accuracy than is generally attainable in any other manner. To apply this technique to the simple single-base method, it is merely necessary to have the roving field altimeter visit a point of known elevation, preferably above the highest field station, about once an hour. The air-density correction factor thus obtained —using the above simple ratio—may be safely applied to all calculations of field-station altitudes visited within plus or minus ½ hour of the time of visit to the point of known elevation. Actual field-test results show an accuracy approaching that of the two-base method.

VARIATIONS IN AIR DENSITY

Another opportunity to enhance the accuracy of altimetry will be found if we investigate the manner in which the density of a vertical column of air varies from a higher density near its base to a generally lower density at its upper extremity. The reason for this variation is simple. First, because air is compressible each successive layer or stratum is compressed by the weight of the total air column vertically above it. Second, there is a general decrease in air temperature with increasing altitude which, taken alone, tends to increase the air density. Third, moisture content generally decreases with increasing altitude, and if taken alone tends to increase the air density—water vapor being less dense than dry air. Taken collectively we have an overall decrease in density with increasing altitude as shown in figure 1. However, because the bottom half of the vertical air column is heavier than the top half, it is known that the location of the layer of average density is somewhat nearer the lower base than the higher base. Next it is seen that, although we may use the foregoing suggested method of altimetry to determine the *average* air density with the best possible accuracy by taking simultaneous readings at two points of known elevation, all it does is to give an *average*. It does not show the manner in which air density varies from the bottom to the top of the vertical column. It is permissible to overlook this disparity provided that the separation of vertical base stations is less than 500 feet. However, as altimetry is most useful in areas of high relief, the accuracy of the results can be improved if we look for a method which will adjust for the manner in which air density at any particular level deviates from the average density of the entire column.

The vertical line coincident with the value of 1.041 in figure 1 represents the average air density for the entire 1,800-foot air column as determined by altimeters at the upper and lower bases. Next, from meteorological tables which are available, the density per foot of air column can be plotted in the manner in which it has been found to vary in actual practice over the entire vertical distance between the base stations. Notice the manner in which it is inclined to our otherwise best effort, which represents only the average air density. Also notice that the intersection with the average air density line occurs at a point below the halfway point between upper and lower base. The adjustment factor to be applied to the *average* air density factor so as to make it conform to the *actual* decrease in air density with altitude is as follows:

$$A = \frac{\frac{\rho_{LB} + \rho_{FS}}{2}}{\frac{\rho_{LB} + \rho_{UB}}{2}}$$

where:

ρ_{LB} = air density at lower base,
ρ_{UB} = air density at upper base,
ρ_{FS} = air density at field station,

A = adjustment factor to adjust average air-density correction factor to actual air-density distribution.

The ratio is computed for each field station and the combined factor is applied to roving altimeter readings as in the two-base method.[2]

THE TILT PLANE

There is yet another factor affecting altimetry accuracy which we may call error due to gradient or error due to the tilt of the plane of equal pressure from the horizontal, and which acts simultaneously with variations in density of the vertical air column. This is illustrated by the fact that two altimeters, reading identically when placed side by side at some point at sea level, will show a difference in reading when one is moved horizontally from the other, both remaining at sea level. The error of gradient can often amount to more than one foot per mile, but is of the order of only ⅓ the magnitude of the probable error due to variations in density of the vertical column. It is proposed, at this point, to determine accurately the correction for horizontal pressure gradient and, separately, the correction for deviation in density of the vertical air column.

First, it is necessary to determine the tilt of the plane of equal atmospheric pressure from the horizontal. Inasmuch as three points determine a plane, a minimum of three base stations are required for this purpose. The ideal set-up would be to have all bases at the same elevation, but horizontally displaced from each other in the shape of an equilateral triangle. When all base stations are at the same elevation, the computations of the tilt of the equal-pressure plane are simplified, as the influence of deviations in density of the vertical air column is eliminated. For the purpose of illustration, let us assume that the area to be surveyed can be segregated as an island, and that three equidistant base stations, *A*, *B*, and *C*, are established around its shore line. (*See* figure 2.) If readings of three sensitive altimeters are compared at one of these base stations, they may be adjusted to read alike, or their separate readings may be noted, and the small amount by which they do not agree becomes the index correction. Next, two of the instruments are taken, one to each of the other base stations, and all three instruments are read simultaneously at their respective locations. The amount by which the readings of the three instruments differ, after applying the index corrections, is an indication of the magnitude and direction of tilt of the plane of equal pressure. If a system of X, Y, and Z coordinates is drawn through the base station, *A*, showing the lowest altimeter reading, with one axis through the second base station, *B*, we can analytically establish the difference in altimeter readings as the Z coordinates for base stations *B* and *C*, as each is compared to the altimeter reading at station *A*. The X and Y coordinates for base stations *B* and *C* can be scaled from a planimetric map or from aerial photographs. Thus the plane of equal pressure as it may be tilted from the horizontal through points *A*, *B*, and *C* becomes established, and to this plane we may reference any field station where an altimeter observation has been made simultaneously with those at the three base stations. The exact amount of horizontal tilt, Z_m, for any field station, *M*, can be determined by inserting its X and Y coordinates and its altimeter reading into an analytical equation. The value of Z_m so determined becomes a correction for tilt of the equal-pressure plane for field station *M*.

Any method for the determination of density of the vertical air column must either be independent of any tilt of the equal-pressure plane, or include a tilt correction for the amount by which the upper base may be horizontally displaced from a lower base. The ideal situation would be to have the upper base vertically above the lower base, such as at the top and bottom of a precipitous cliff. The solution for air density is essentially that of the well known two-base method and it is therefore not repeated here. Naturally, as already shown, the computation should include adjustment for the

[2] A method of performing this computation will be furnished on request to Wallace and Tiernan, Inc., Belleville, N. J.

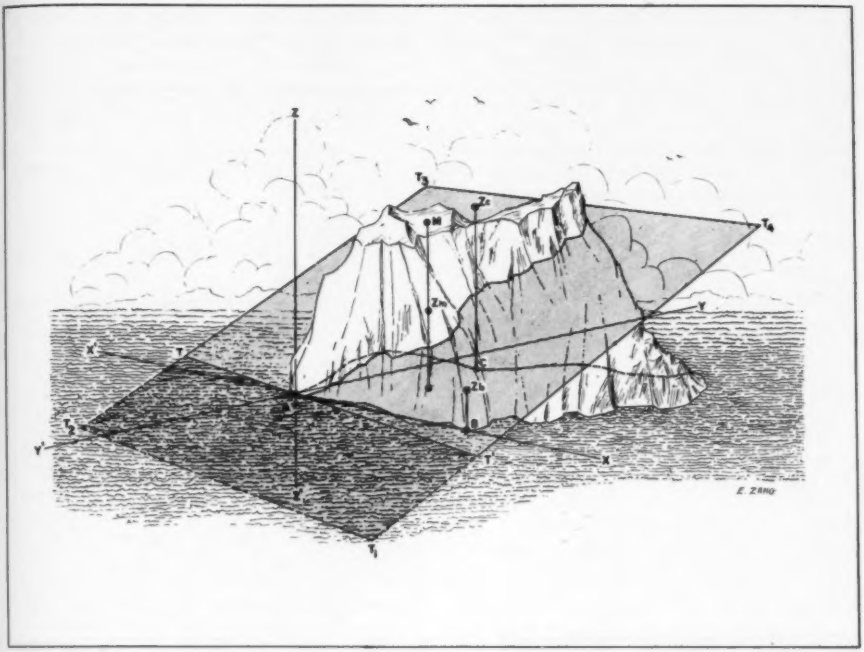

FIGURE 2.

manner in which air density of the vertical air column varies with altitude, if a large vertical base separation is involved.

Likewise, and as previously stated, any method for the determination of degree and direction of tilt of the equal-pressure plane must be independent of deviation in density of the vertical air column, or include a correction for such air-density deviations in the computations. Therefore, the ideal situation is to have three low bases all at the same elevation.

When the two determinations are combined into one field set-up and the resultant multiple-base procedure is adapted to a typical area of topographical relief, the solution becomes a little more complex. One analytical solution has already been published.[3]

[3] *See* "Multiple-Base Altimetry," by A. H. Mears and W. F. Haring, *Photogrammetric Engineering*, December 1954.

SUMMARY

This presentation has been purposely limited to an explanation of multiple-base altimetry in its elementary form in the belief that the factors which have limited accuracy in the past must first be fully understood. These limiting factors and means for their mitigation include:

1. Inability to determine true average air density through the use of thermometers and psychrometers. It is recommended that the altimeter itself be used for this purpose under all field procedures.

2. Determination of field-station elevations under the two-base method based solely upon the average air density, without adjustment for the manner in which air density per foot of height varies over the entire vertical air column. The slight extra work of applying this additional air density distribution adjustment is recommended wherever the vertical base separation is over 500 feet.

3. Although the two-base method also corrects for deviation in density of the vertical air column from standard conditions, it does not separate and make correction for tilt of the equal-pressure plane from the horizontal. In order to extend the usefulness of altimetry into areas of high relief and under atmospheric conditions heretofore considered too adverse for altimetry, and above all to improve the accuracy of the results, it is recommended that multiple-base altimetry be adopted.

These improvements in altimetry techniques will dictate a corresponding re-evaluation of the economies thus made possible. The higher accuracies should make altimetry applicable for all projects where its degree of precision cannot be obtained at less expense by other methods. The cost of altimetry has become primarily the expense of man-hours of travel time. The most suitable, fastest, and most economical conveyance for travel from point to point over the survey area becomes a principal consideration.

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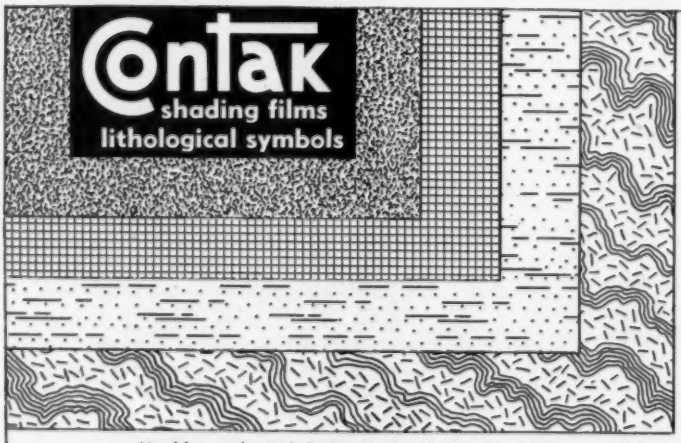

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General Interest

OUR NEWEST FRONTIER—THE OUTER CONTINENTAL SHELF. Sidney M. Groom, Jr. *Our Public Lands,* Vol. 5, No. 1, January 1955. (A discussion of the operation by the Bureau of Land Management under the provisions of the Outer Continental Shelf Lands Act of 1953.)

SCIENTIFIC PROGRAMME OF THE INTERNATIONAL GEOPHYSICAL YEAR 1957–58. Prof. Sydney Chapman. *Nature,* Vol. 175, No. 4453, March 5, 1955. (Summary of the plans for this very auspicious scientific event.)

ARMY TO USE 50 COPTERS FOR BUSH SURVEY. (News article.) *Aviation Week,* Vol. 62, No. 18, May 2, 1955. (Account of aircraft use on topographic surveys projected in Alaska and Iceland during the 1955 season.)

BOUNDARY PROBLEMS RAISED BY THE SUBMERGED LANDS ACT. A. L. Shalowitz, *Columbia Law Review,* Vol. 54, No. 7, November 1954. (A comprehensive discussion of the problems and solutions in the context of historical precedents in the judicial, legislative, and executive fields. A limited number of reprints of this paper are available on request to the Director, U. S. Coast and Geodetic Survey, Washington 25, D. C.)

Control Surveys

NORTHERN ACTIVITIES OF THE GEODETIC SURVEY, 1954. *The Arctic Circular,* Vol. 7, No. 4, December 1954. (Brief report on the season's work in the Canadian north.)

CONTROL SURVEYS FOR THE RIMUTAKA RAILWAY TUNNEL. D. R. Brenchley. *The New Zealand Surveyor,* Vol. 21, No. 3 (whole No. 207), February 1955. (Describes survey work preliminary to construction of the longest railway tunnel in the British Commonwealth.)

VARIOUS DETERMINATIONS OVER A CENTURY OF THE HEIGHT OF MOUNT EVEREST. J. de Graaf-Hunter. *The Geographical Journal,* Vol. 121, Part I, March 1955. (An account of the attack on the problem by various triangulators and astrolabe observers over a period of more than a century.)

EARTH WORK VOLUMES—THE PRISMOIDAL CORRECTION. Peter N. Ray. *Empire Survey Review,* Vol. 13, No. 96, April 1955. (Application of the "prismoidal correction" in the calculation of earthwork volume by the "methods of end areas.")

A COMPARISON OF THREE METHODS USED FOR CALCULATING THE LONGITUDE FROM A PAIR OF WELL BALANCED STARS. J. G. Freislich. *Empire Survey Review,* Vol. 13, No. 96, April 1955.

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THE TRIANGULATION OF CULTIVATION OVERLOOKED BY HIGH GROUND. J. W. Wright. *Empire Survey Review,* Vol. 13, No. 96, April 1955. (Concluded from No. 95.)

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AN EXPERIMENT IN AERIAL TRIANGULATION. Lt.-Col. B. St. G. Irwin, R. E. *The Photogrammetric Record,* Vol. 1, No. 5, April 1955. (Describes an experiment using a master block of medium-scale air photography to control a block of large-scale photography thereby effecting economy in the amount of ground control required.)

Property Surveys

SURVEYS SPUR SETTLEMENT. Earl G. Harrington. *Our Public Lands,* Vol. 5, No. 1, January 1955. (Brief discussion of the relation of cadastral surveys to the opening and settlement of the West.)

CURVED-TO-CONTOUR DESIGN V. STRAIGHT-LINE DESIGN. T. McK. Runciman. *The New Zealand Surveyor,* Vol. 21, No. 3 (whole No. 207), February 1955. (Presents arguments favoring curved-to-contour street and property layouts in residential developments on grounds of economic advantage, attractiveness, and, above all, safety.)

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THEY'VE CORNERED THE COUNTRY. Harry Kursh. *Our Public Lands,* Vol. 5, No. 2, April-June 1955. (Brief article, reprinted from *Steelways,* American Iron and Steel Institute, describing progress over more than a century in establishing permanent corner markers.)

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MEDIEVAL LAND SURVEYING AND TOPOGRAPHICAL MAPS. Derek J. Price. *The Geographical Journal,* Vol. 121, Part I, March 1955. (A historical investigation to determine what instruments and techniques for surveying and mapping were in use before 1500.)

HISTORICAL MAPS AS AN AID TO RESEARCH. Prof. C. Hoeman, Technical University, Delft, Holland. (Letter to the editor.) *South African Journal of Science,* Vol. 51, No. 9, April 1955. (Describes his visit to South Africa where he informed scholars of his research in Holland in the field of South African cartography and history and of his discovery of extensive collections of maps and map manuscripts hitherto unknown to the South Africans.)

AITOFF AND HAMMER: AN ATTEMPT AT CLARIFICATION. John B. Leighly. *The Geographical Review,* Vol. 45, No. 2, April 1955. (An analysis of the contributions of each of the cartographers for the purpose of separating the two names, crediting each with a different projection.)

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THE "KUIPERS" LIGHT SPOT PROJECTOR. G. Kuipers with an introduction by B. Scherpbier. *Photogrammetria,* Vol. 11, 1954–1955, No. 2. (Describes an instrument for the compilation of maps from aerial photographs taken with a wide-angle lens, in vertical or oblique direction.)

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A NEW PLOTTING MACHINE FOR AIR PHOTOGRAPHS. J. E. Odle. *The Photogrammetric Record,* Vol. 1, No. 3, April 1954. (Description of new Williamson multiplex plotter.)

PHOTOGRAPHY SPEEDS TRIANGULATION. (New Products Section.) *Engineering News-Record,* Vol. 154, No. 15, April 14, 1955. (Describes instrument on which readings are recorded on film effecting a saving of time and effort and relieving the observer of the necessity for continuous reading.)

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MAP MAKING FILMS HELP TEACH CARTOGRAPHY. Bernard J. Colner. *Public Works,* February 1955. (Describes the different motion pictures available to help explain different aspects of the mapping field.)

SURVEYING TECHNIQUES FOR NIGERIAN UNIVERSITY STUDENTS. J. C. Pugh. *Empire Survey Review,* Vol. 13, No. 96, April 1955. (Details of a course given at University College, Ibadan, Nigeria.)

WHAT'S WRONG WITH ENGINEERING EDUCATION. Herman L. Danforth. *Civil Engineering,* Vol. 25, No. 5, May 1955. (Critical appraisal of the subject.)

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THE FIELD STUDY OF PLACE—A PRACTICAL GUIDE. A. J. Wraight. *University Press of Washington,* D. C., 1954. 98 pages, 17 illustrations, folded air photo and prototype topographic map, stadia tables, index. Price $2.25.

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PLANE AND GEODETIC SURVEYING FOR ENGINEERS. David Clark. Vol. 1: Plane Surveying. Fourth edition, revised and enlarged. London, *Constable and Co., Ltd.* 1954. 636 pp.

COMMON MAP PROJECTIONS (GRATICULES): CHARACTERISTICS AND USES. C. E. Abelson. Sevenoaks, Kent, England, 1954. 29 pp. (Published by the author and distributed by W. H. Smith and Son, Sevenoaks, Kent, England.)

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BE EXPERT WITH MAP AND COMPASS: THE "ORIENTEERING" HANDBOOK. Bjorn Kjellstrom. *American Orienteering Service*, New York, 1955. 136 pp., illustrations, maps.

—LYMAN D. LYNN

DISTINCTIVE RECENT MAPS

Georg Westerman Verlag, Braunschweig, Germany, published in 1953 a large, colorful, wall map showing vegetation regions of the world (*Vegetationsgebiete der Erde*). Prepared under the direction of Prof. Dr. O. Maull, the map shows some 30 generalized vegetation regions. It is at the scale of 1:18,000,000 and measures 49 by 77 inches.

Denoyer-Geppert Map Company of Chicago has introduced a new "Relief-Like" series of school wall maps with the recent publication of the map of *Continental United States*. Shading, as perfected by the Wenschow firm of Germany, has been skillfully combined with hypsometric tints to give a three-dimensional quality to topography. The map, which is at the scale of 1: 3,000,000, was prepared under the editorial direction of C. C. Colby. The measurements are 44 by 64 inches.

Foreign Map Catalog No. FM55, issued recently by Denoyer-Geppert Company, lists the above map as well as a number of other maps published in foreign countries. Requests for the catalog may be directed to the company at 5235 Ravenswood Avenue, Chicago 40, Ill.

A Map of New England With Descriptive Notes was the June 1955 supplement to the *National Geographic Magazine*. The large (41 by 38 inches) ten-color map includes 4,442 place names and 553 descriptive notes, largely historical. The scale is 12 miles to the inch. A separate pamphlet indexing the place names and descriptive notes is available from the National Geographic Society at 25 cents per copy. Additional copies of the map may be ordered for 50 cents (on paper) or one dollar (on cloth).

The Oil and Gas Journal's maps of *United States and Canadian Natural-Gas Pipe-Line Systems*, and *United States and Canadian Crude-Oil and Products Pipe-Line Systems* are printed on opposite sides of a large map sheet copyrighted in 1955 by Petroleum Publishing Company (E. C. Jacobson) of Tulsa, Okla.

The maps measure approximately 40 by 56 inches and are at the scale of 1:3,350,000. Natural Gas, Principal Products, and Crude-Oil Pipe-Line Systems are listed at the bottom of the sheet.

The U. S. Geological Survey has published recently, with the cooperation of State agencies, new geologic maps of Oklahoma and Wyoming. Both are at the scale of 1: 500,000. Collaborating in the compilation of the former were the Oklahoma Geological Survey, oil companies and independent geologists of Oklahoma, geology departments of the several universities and colleges in the State, and the U. S. Soil Conservation Service and Bureau of Reclamation.

The Oklahoma map, which measures approximately 36 by 69 inches, shows formations ranging in age from Cambrian to Quaternary. Valuable features of the map are a list of sources used in

its compilation and a "Key Map of Oklahoma Showing Principal Sources of Geologic Maps."

The *Geologic Map of Wyoming* was prepared with the cooperation of the Geological Survey of Wyoming and the Department of Geology, University of Wyoming. The geology shown was compiled from more than 200 detailed and reconnaissance maps. As on the Oklahoma map, sources of material used are shown on a small inset map. The Wyoming map measures 50 by 72 inches and shows 142 geologic units, each identified by a pattern that is printed in one of 17 different colors, chosen to represent major divisions of geologic time.

The Hotchkiss Mapping Company, of Denver, Colo., copyrighted in 1954 a *New Mexico Oil and Gas Map*. In addition to administrative and cultural information, the map shows oil and gas fields, dry or abandoned wells, gas and oil pipelines, anticlinal and "concealed anticlinal" axes, and outcrops of pre-Cambrian and volcanic rocks. A small inset map outlines major structural basins of the State. Location, production, and depth data on pools are listed in a table on the map sheet. The scale of the map is 1:1,000,000 and the size approximately 20 by 31 inches.

The quest for uranium has created a demand for maps which will guide the prospector. A recent response to this demand is the *Geologic and Uranium Claim Map of the Lisbon Valley—Big Indian Mining District in San Juan County, Utah*. It was copyrighted in 1955 by Western States Map Co., Salt Lake City, Utah. The map shows limits of claims, as well as major geologic formations, faults, strike and dip of beds, mines, and ore bodies or mineralized zones. The scale is 1:50,000 and the size 21 by 30 inches.

Bell Mapping and Engineering Company, Grand Junction, Colo., copyrighted early in 1955 a *Uranium Prospecting Map* [of] *Dolores, San Juan, Montezuma & La Plata Counties, Colorado*. The map, reproduced as a blue-line print, shows producing uranium mines, and outlines the extent of the Morrison (most important uranium producer), Entrada Sandstone (important vanadium producer, minor uranium), and Upper Triassic rock formations. The map sheet measures 38 by 46 inches and the scale is approximately 1:125,000.

Canada—1967 looks ahead some 12 years when Canada will celebrate its one hundredth anniversary. The colorful pictorial map, by William Parlane, pictures "100 important new resources that will help make Canada's 100th birthday a bright and prosperous one." A table gives population, resource production and trade statistics for 1867, and estimated figures for 1954 and 1967. The map was published by Canadian General Electric Company and reproduced by Rolph-Clark-Stone Ltd. of Toronto. It measures 20 by 28 inches. The scale is "as big as your horizon."

The British Ministry of Housing and Local Government has recently issued two maps which are of cartographic, statistic and economic interest. *Population of Urban Areas 1951*, published in 1954 shows numbers of persons in urban areas by means of proportional circles. "The area of each circle is proportional to the population of the Administrative Area, except that circles of minimum size, corresponding to populations of 1,000, also represent the populations of four towns under 1,000."

The second map, dated 1955, shows *Local Accessibility, The Hinterlands of Towns and Other Centres as Determined by an Analysis of Bus Services*. Orange circles identify population centers, and a green outer circle indicates the extent of the hinterland. Both maps were printed by the Ordnance Survey on the O. S. standard two-sheet, 1:625,000 base map. Only the south sheet of the *Population* map has been received.

British European Airways, in association with five related airlines, has issued a colorful pictorial map of Europe entitled *BEA International Air Routes*. Sketches on the face of the map illustrate native costumes, distinctive activities, economic products, and scenic attractions in the several countries. Cartography is by "Hawes," with lithography and printing by George Philip & Son. The map is 34 by 44 inches with a scale of 1:6,000,000.

The high-tension electrical network of Belgium is shown on a map published in 1954 by the Institut Géographique Militaire, Brussels. It is entitled *Belgique Reseaux Electriques a Haute Tension*. The map measures approximately 26 by 30 inches and is at the scale of 1:400,000.

Erhvervsgeografisk Kort over Danmark presents economic and resource data of Denmark, the Faeroe Islands, and Greenland. It was compiled in the Universitetets geografiske Laboratorium and published in 1953 by the Geodaetisk Institut Köbenhavn).

The map is at the scale of 1:300,000 and is printed on two sheets each measuring approximately 30 by 44 inches. When mounted and joined they form a large wall map suitable for classroom use.

Die Industrie der Bundesrepublik shows the distribution of various workers, by major industry groups, in western Germany. It was compiled by Statistischen Bundesamt and published by Bundesanstalt für Landeskunde. The map, which measures 36 by 26 inches, is at the scale of 1:1,000,000.

A *Communication Map of Egypt* has been prepared and published, in 1955, by the Cairo Drafting Office, and printed by Institut Graphi-

que Egyptien. At the scale of 1:1,000,000, the map shows internal administrative boundaries, cities and towns, airports, two classes of railways, three classes of roads and rivers, canals and drains. There is an inset map of *Egypt & Sudan* at the scale of 1:7,161,000. The full map sheet measures 37 by 26 inches.

République Populaire de Chine is the title of a map of the Peoples Republic of China published in 1954 by Paris-Pekia, Paris, France. It shows generalized relief by gradient tints, administrative boundaries, railroads, and major mineral deposits. Brief descriptive data and geographical facts are printed on the right and left margins of the map. The scale is approximately 1:12,000,000 and the sheet size 19 by 24 inches.

The political importance of Taiwan (Formosa) gives especial interest to the *Geologic Map of Taiwan* published in 1953 by Geological Survey of Taiwan. It was prepared by Li-Sho Chang under the direction of Biq Chingchang. Title and legend are in Chinese and English.

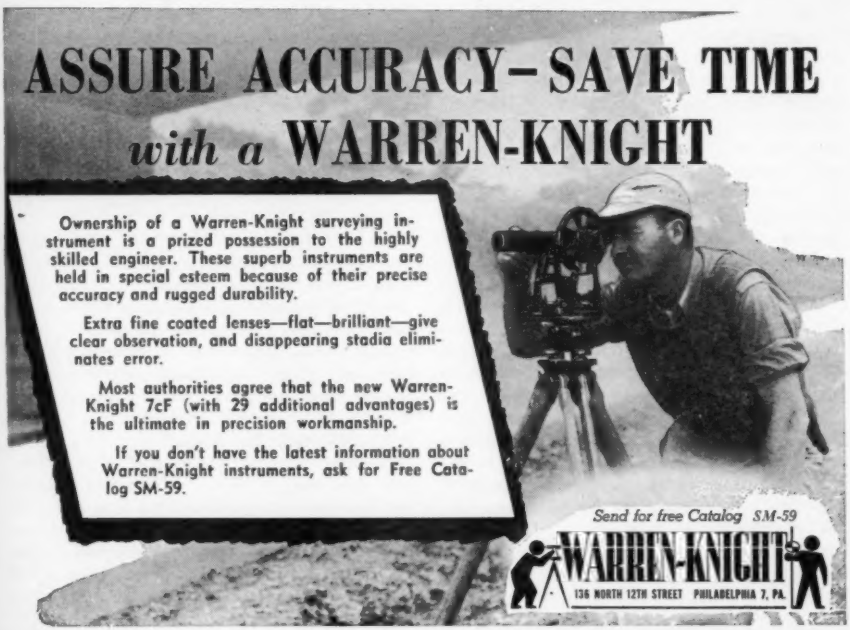
The map is printed on two sheets each measuring approximately 29 by 39½ inches. The scale is 1:300,000. On a contoured base map, colors and symbols identify some 25 formations ranging from "Age Unknown" and late Paleozoic to Recent gravel, sands, and clays. Formations in general have a northeast-southwest alignment, parallel to the axis of the island.

The *Northern Territory of Australia* is shown in shaded relief on a map compiled and drawn by the National Mapping Office and Published at Canberra in 1953 by the [Australian] Department of the Interior. Two classes of highways, railway lines, territorial and state boundaries, homesteads, and spot elevations are also shown. The map, which is at the scale of 1:2,000,000, measures 36 by 24 inches.

A road map of *Tasmania* showing generalized relief by hypsometric gradients, was published in 1952 by the Mapping Branch, Lands and Surveys Department, Hobart [Tasmania]. The scale is ten miles to one inch and the size 25½ by 20½ inches. In addition to topography and several classes of roads, the map shows railways, tracks (i.e. trails), aerodromes, elevation of major peaks, and municipal boundaries. Highway mileages between the major cities are given in a table.

—Walter W. Ristow
Library of Congress

₹ ₹ ₹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Books in Review

GEOGRAPHY OF THE NORTHLANDS. Edited by George H. T. Kimble and Dorothy Good. Articles written by a group of fifteen Arctic specialists. Special Publication No. 32 of the American Geographical Society of New York. Published in cooperation with *John Wiley & Sons, Inc.*, New York, 1955. 534 pages, including index. Map of the Northlands tipped into back cover. $10.50.

In the late 1920's Dr. Isaiah Brown, then Director of the American Geographical Society, inaugurated a series of research studies of the polar regions. These studies Dr. Bowman rightfully concluded should be based on scientific research and should be in the nature of an appraisal and description of the physical and cultural landscapes that comprise these regions, by authorities in the field. Significant among the contributions that were forthcoming on this subject and area by the Society were two basic publications: (1) *Problems of Polar Research; A Series of Papers by Thirty-One Authors,* Special Publication No. 7, edited by W. L. G. Joerg and published in 1928; and (2) *The Geography of the Polar Regions, Consisting of a General Characterization of Polar Nature by Otto Nordenskjold, and A Regional Geography of the Artic and Antarctic by Ludwig Mecking,* Special Publication No. 8, translated and edited by W. L. G. Joerg and Marion Hale and published in 1928. These represented milestones in the diffusion of knoweldge about the polar regions and went far, not only in presenting an up-to-date, factual, readable, scientific discussion of these regions, but in serving to establish the American Geographical Society, and especially W. L. G. Joerg, as among the leading American authorities in this field. These and other related publications of the Society serve as a kind of datum from which subsequent similar publications should be measured.

It is indeed fitting that some twenty-five years later the American Geographical Society should reappraise the geography of the Northlands and once again assemble a corps of specialists to undertake the by no means easy task of preparing a publication of the same quality and scope as Special Publication No. 7, for during and since World War II the Arctic and sub-Arctic have gained an importance perhaps even greater than that forecast by its exponents of the late 1920's. Man's phenomenally rapid strides in science and technology and his ability to penertate seemingly at will and according to plan the remotest and least hospitable of regions, have given him virtual command of the Northlands. How he has accomplished this and the change that he has wrought are exciting chapters in modern history. Indeed, *Geography of the Northlands* in telling the story goes far toward bringing us up to date.

It is perhaps fitting that most of the authors of this cooperative enterprise are Canadians and subject specialists in things polar for, with a wide window onto the Northlands and an accelerated program of scientific investigation of that region, especially under the auspices of the government and McGill University, they have become singularly proficient in this field of endeavor. Most of the authors have published widely in the field of their specialty and in this have had the assistance of the Arctic Institute of North America, whose ten years of active participation in Arctic research is at least in part reflected in this publication.

This book is divided into two principal parts: (1) Systematic Studies (of which there are twelve), pages 11–291; and (2) Regional Studies (of which there are fourteen), pages 292–486.

Part I includes systematic studies in the fields of physiography, weather and climate, water masses and circulation, ice cover, biogeography, marine life, aboriginal and immigrant populations, transportation, renewable and nonrenewable resources, and the political and strategic aspects. Each of these chapters presents a nicely compacted source of generalized though factually correct scientific information as it is generally accepted by most authorities today. The authors are aware of the fact that there are many gaps in and questions as to accuracy of a good deal of our present-day knowledge of the Northlands. Accordingly, the reader finds qualifying phrases and sentences such as "according to these criteria," "other definitions may be found," "it is generally recognized," and "for the purpose of this study," that flag portions of the information that are not uniformly acceptable. This is to the credit of the authors and is evidence of objective presentation. This part of the book is commendable for the wealth of information and the fresh up-to-date approach that has been taken in its presentation.

Part II is a regional geography of the Northlands. Each region apparently is not treated in accordance with the same plan of presentation. It appears that generally each of these chapters includes a descriptive definition of the area encompassed within each region (i.e. Alaska, Greenland, Canadian Arctic Archipelago, and Iceland), a description of the physical landscape, and a description of the cultural landscape. This is a rather large order and, because of the considerable development of the cultural landscape during the past twenty-five or thirty years, cannot be adequately portrayed in so few pages. For example, only fourteen pages (pages 372–385) are given to Greenland, and twenty-two pages (pages 293–313) are given to Alaska. It is even more striking that only sixty-six pages (pages 433–498) are given to the U.S.S.R. whose extensive land and water area in the Northlands, its considerable population, and extensive activities and development in these regions should warrant a much greater discussion. These regional descriptions are, however, very helpful to the reader in search of good, general, thumbnail sketches. To this reviewer, however, they do not quite measure up to the standards required as companion studies to those of Part I. The editors were aware of this possibility, for in their preface they note that ". . . we will readily concede that a good deal of the 'common ground' has been tripped over rather lightly, to the discomfiture, we suspect, of our long-suffering collaborators . . .," and that their "assignment has necessitated the use of a large brush" (page vii).

This reviewer feels rather strongly that in a general study such as this there is perhaps serious need of acquainting the reader with a few of the basic, detailed, readily available, comprehensive sources, such as, for example, the monumental five-volume *Arctic Bibliography* (33,125 entries) prepared under the direction of the Arctic Institute of America and edited by Marie Tremaine. Such a reference might well have been noted in the introduction and in the "Selected References" at the end of most chapters. This is a startling and serious omission. Also, the nearly total lack of footnotes and similar documentation, especially covering significant statements of fact and statistical and similar data, tends to detract from what generally appears to be an outstanding contribution to our knowledge of the Northlands. No mention is made in the introduction or the list of references, where one would expect it, of the two predecessor special publications (Nos. 7 and 8) of the American Geographical Society, noted above.

A few errors in spelling have crept into the otherwise well-written publication. For example, on page 316 "sedimentary" is spelled "sedementary." This reviewer is amazed that certain words such as year (yr.), mile (mi.), feet (ft.), square mile (sq. mi.), month (mo.), and square kilometer (sq. km.) are used in the abbreviated form throughout the text, yet words such as barrels and board feet are not abbreviated. Also, the authors have not standardized measures. For example they use kilometer and miles indiscriminately, which makes for difficulties to the average reader. It would have been better to have converted all to one system. Another example of incongruity is on page 221 where the forests of Alaska are given in millions of acres and on the same page the forests of Canada are given in square miles.

This volume is well illustrated with neatly- and clearly-drawn maps, useful descriptive photographs, and clear graphs and diagrams. The cartographer especially is to be commended for his craftsmanship.

This publication is heartily recommended as one of the best recent contributions to the geography of the Arctic and sub-Arctic and should be among the selected publications on the shelf of every library.

HERMAN R. FRIIS
The National Archives

1955 ACSM-ASP CONSECUTIVE MEETINGS AND CO-EXHIBIT

March 19–24, 1956, Washington, D. C.

MAP INFORMATION

This department was inaugurated for the purpose of bringing to the attention of the members information pertaining to the availability of maps, surveys, etc., with particular emphasis on how such material can be procured. It is believed that through an interchange and dissemination of such information maximum benefits will accrue to the surveying and mapping profession. —EDITOR

U. S. Geological Survey Topographic Maps

THE FOLLOWING quadrangle maps were published by the U. S. Geological Survey between March 1 and May 31, 1955. The list includes newly compiled maps; revised maps on which contours and drainage usually are unchanged but the works of man are brought up to date; and series-converted maps which are 15-minute maps produced from four 7½-minute maps of the same area. The maps are new unless otherwise designated by numerical superscript.

The quadrangle name (in capital letters) is followed by the name of the county (in upper- and lower-case letters) that contains the place or feature for which the quadrangle is named.

All maps are available with or without the green overprint that indicates woodland. These maps show the shape and elevation of the land surface (represented by contour lines, printed in brown); water features (in blue); works of man, including cities, towns, scattered habitations, schools, churches, railroads, roads, and boundaries, and place and feature names (in black); and woodland areas (in green). Principal roads are shown by a red overprint. In areas that have been covered by Bureau of Land Management surveys, township and section lines are shown. The State rectangular coordinate systems are indicated in the margins of the maps. An information folder further describing topographic maps is available on request.

Standard quadrangle maps may be obtained for 20 cents per copy. A discount of 20 percent is allowed on orders amounting to $10 or more at the retail price. Orders should be addressed to the U. S. Geological Survey, Washington 25, D. C., (or Denver 15, Colo., for maps of areas west of the Mississippi River.)

Alaska

AFOGNAK (A-0 and B-0)*—Third Judicial Division
AFOGNAK (A-5)*—Third Judicial Division
AFOGNAK (B-4)*—Third Judicial Division
HAGEMEISTER ISLAND (C-2)*—Third Judicial Division
HAGEMEISTER ISLAND (C-3)*—Third Judicial Division
HAGEMEISTER ISLAND (C-4)*—Third Judicial Division
HAGEMEISTER ISLAND (C-5)*—Third Judicial Division
HAGEMEISTER ISLAND (C-6)*—Third Judicial Division
HAGEMEISTER ISLAND (C-7)*—Third Judicial Division
HAGEMEISTER ISLAND (D-1)*—Third Judicial Division
HAGEMEISTER ISLAND (D-2)*—Third Judicial Division
KETCHIKAN (B-5)*—First Judicial Division
KETCHIKAN (B-6)*—First Judicial Division
KETCHIKAN (D-5)*—First Judicial Division
KETCHIKAN (D-6)*—First Judicial Division
LIVENGOOD (A-2)*—Fourth Judicial Division
LIVENGOOD (A-3)*—Fourth Judicial Division
LIVENGOOD (A-4)*—Fourth Judicial Division
LIVENGOOD (B-1)*—Fourth Judicial Division
LIVENGOOD (B-2)*—Fourth Judicial Division
LIVENGOOD (B-4)*—Fourth Judicial Division
LIVENGOOD (C-1)*—Fourth Judicial Division
LIVENGOOD (C-2)*—Fourth Judicial Division
LIVENGOOD (C-3)*—Fourth Judicial Division
LIVENGOOD (D-2)*—Fourth Judicial Division
LIVENGOOD (D-4)*—Fourth Judicial Division
NUSHAGAK BAY (B-3)*—Third Judicial Division
NUSHAGAK BAY (B-4)*—Third Judicial Division
NUSHAGAK BAY (C-3)*—Third Judicial Division

* Indicates 15-minute quadrangle; all others are 7½-minute quadrangles.
[1] Indicates a revised map. [2] Indicates a series-converted map.
† Indicates availability in either a contour or a shaded-relief edition.

NUSHAGAK BAY (C-4 and C-5)*—Third Judicial Division
NUSHAGAK BAY (D-4)*—Third Judicial Division
SELDOVIA (A-3)*—Third Judicial Division
SELDOVIA (A-4)*—Third Judicial Division
SELDOVIA (A-5)*—Third Judicial Division
SELDOVIA (A-6)*—Third Judicial Division
SELDOVIA (B-3)*—Third Judicial Division
SELDOVIA (B-4)*—Third Judicial Division
SELDOVIA (B-5)*—Third Judicial Division
SELDOVIA (C-1)*—Third Judicial Division
SELDOVIA (C-2)*—Third Judicial Division
SELDOVIA (D-1)*—Third Judicial Division
SELDOVIA (D-2)*—Third Judicial Division
SELDOVIA (D-3)*—Third Judicial Division
SITKA (A-4)*—First Judicial Division
VALDEZ (A-3)*—Third Judicial Division
VALDEZ (A-4)*—Third Judicial Division
VALDEZ (A-5)*—Third Judicial Division
VALDEZ (C-4)*—Third Judicial Division

Alabama

CHICKASAW[1]—Mobile
HOLLINGERS ISLAND[1]—Mobile
SILVERHILL[1]—Baldwin
STAPLETON[1]—Baldwin
THEODORE[1]—Mobile

Alabama-Georgia

ELLERSLIE*[2]—Harris
LUMPKIN*[2]—Stewart
SEALE*[2]—Russell

Arizona

JACOB LAKE*[1]—Coconino

Arkansas-Mississippi-Tennessee

HORSESHOE LAKE*[1]—Crittenden

California

ALBERHILL—Riverside
ANTIOCH NORTH—Contra Costa
BETHANY—Alameda
BRAWLEY*—Imperial
BRECKENRIDGE MOUNTAIN*—Kern
BUNKER HILL—Placer
CLOVIS*[2]—Fresno
COOPERSTOWN[1]—Stanislaus
DENAIR[1]—Stanislaus
DOUBLE POINT—Marin
DUBLIN—Alameda
ELMIRA—Solano
FARMINGTON[1]—San Joaquin
GOOSE CREEK[1]—San Joaquin
KAISER PEAK—Fresno
KELLER PEAK—San Bernardino
LA JOLLA[1]—San Diego
LA MESA[1]—San Diego
LINCOLN[1]—Placer
LOS GATOS—Santa Clara
MILPITAS—Santa Clara
MONTPELIER[1]—Stanislaus
MOUNTAIN VIEW—Santa Clara
MT. MORRISON—Mono
NILES[1]—Almeda
PANTHER SPRING*—Tehama
PARADISE*—Butte
PATTERSON MOUNTAIN*—Fresno
PAULSELL[1]—Stanislaus
POND—Kern
RIVERSIDE EAST—Riverside
ROSEVILLE—Placer
ROYAL GORGE—Placer
SADDLE MOUNTAIN*[2]—El Dorado
STEELE PEAK—Riverside
TEHIPITE DOME—Fresno
TURLOCK LAKE[1]—Stanislaus
WENTWORTH SPRINGS—El Dorado
WILDOMAR—Riverside
ZAMORA—Yolo

Colorado

BLACK FOREST—El Paso
CHERRY VALLEY SCHOOL—Douglas
COOPER MOUNTAIN—Fremont
EASTONVILLE—El Paso
ELLICOTT—El Paso
GREENLAND—Douglas
HAEGLER RANCH—El Paso
HANOVER—El Paso
HANOVER NW—El Paso
LARKSPUR—Douglas
LITTLE CONE—San Miguel
MONUMENT—El Paso
MOUNT DECEPTION—Teller
PHANTOM CANYON—Fremont

Connecticut

BROAD BROOK[1]—Tolland
ELLINGTON[1]—Tolland
FITCHVILLE[1]—New London
HAMPTON[1]—Windham
JEWETT CITY[1]—New London
LONG HILL—Fairfield
NEWTON—Fairfield
PLAINFIELD[1]—Windham
ROCKVILLE[1]—Tolland
SOUTH COVENTRY[1]—Tolland
STAFFORD SPRINGS[1]—Tolland

Connecticut-Rhode Island

ASHAWAY[1]—Washington

Florida

BITHLO—Orange
CHILDS—Highlands
DAVENPORT—Polk
FELLSMERE 4 SE—Indian River
GENEVA—Seminole
INDIAN TOWN NW—Martin
INDIAN TOWN SE—Martin
INTERCESSION CITY—Osceola
LAKE JESSAMINE—Orange
LAKE POINSETT—Brevard
LAKE POINSETT NW—Orange
NARCOOSSEE NE—Orange
NARCOOSSEE NW—Orange
OKEECHOBEE 1 NE—Orange
OVIEDO—Orange
TITUSVILLE SW—Brevard
WINDERMERE—Orange

Georgia

BUENA VISTA*[2]—Marion
TALBOTTON*[2]—Talbot

Idaho

CLOVERDALE—Ada
MANN CREEK*—Washington
MERIDIAN—Ada

Illinois

ARLINGTON HEIGHTS[1]—Cook
BEECHER WEST—Will
CHANNAHON—Will
COAL CITY—Grundy
ELMHURST[1]—Du Page
ELWOOD—Will
FRANKFORT—Will
HIGHLAND PARK[1]—Lake
LISBON—Kendall
LOMBARD—Du Page
MINOOKA—Grundy
MOKENA[1]—Cook
MORRIS—Grundy
NAPERVILLE—Du Page
NORMANTOWN—Will
PALATINE—Cook
PALOS PARK[1]—Cook
PEOTONE—Will
PLAINFIELD—Will
PLATTVILLE—Kendall
ROMEOVILLE—Will
STEGER—Cook
SYMERTON—Will
TINLEY PARK[1]—Cook
WHEATON—Du Page
WHEELING[1]—Cook
WILMINGTON—Will
WILTON CENTER—Will
YORKVILLE—Kendall
YORKVILLE SE—Kendall

Illinois-Indiana

DYER—Lake

Indiana

CHESTERTON—Porter
CROWN POINT—Lake
DANVILLE—Porter
DUNE ACRES—Porter
GARYTON—Porter
GUILFORD[1]—Dearborn
HEBRON—Porter
HIGHLAND—Lake
KOUTS—Porter
LOWELL—Lake
MICHIGAN CITY WEST—La Porte
NOBLESVILLE—Hamilton
OGDEN DUNES—Porter
PALMER—Lake
PLAINFIELD—Hendricks
RIVERWOOD—Hamilton
ST. JOHN—Lake
VALPARAISO—Porter

Indiana-Kentucky

ABERDAEN[1]—Ohio
BETHLEHEM—Clark
ROME—Perry

Kansas

LAKE McBRIDE—Scott

Kentucky

ALEXANDRIA—Campbell
AUSTIN—Barren
BERRY—Harrison
BOLTSFORK—Boyd
BOONEVILLE—Owsley
BRECKINRIDGE—Harrison
BURKESVILLE—Cumberland
BUTLER—Pendleton
CREELSBORO—Russell
CUB RUN—Hart
DE MOSSVILLE—Pendleton
DUBRE—Cumberland
DUNNVILLE—Casey
EAST FORK—Metcalf
FAIRFIELD—Nelson
FALMOUTH—Pendleton
GOFORTH—Pendleton
HODGENVILLE—Larue
JAMESTOWN—Russell
KELAT—Harrison
KIRKMANSVILLE—Todd
LEIGHTON—Estill
LOAD—Greenup
MAULDEN—Jackson
MAZIE—Lawrence
MIDWAY—Woodford
MILL SPRING—Wayne
MISTLETOE—Owsley
MONTICELLO—Wayne
PARIS WEST—Bourbon
PARNELL—Wayne
PELLVILLE—Hancock
POLSGROVE—Franklin
RAYWICK—Marion
RUSH—Boyd
SPURLINGTON—Taylor
STAMPING GROUND—Scott
TYNER—Jackson
TYRONE—Anderson
WEBBVILLE—Lawrence
WHITESVILLE—Daviess
WILLARD—Carter

Kentucky-Indiana
CLOVERPORT—Breckenridge
TELL CITY—Perry

Kentucky-Ohio
NEW RICHMOND—Clermont

Kentucky-West Virginia
FALLSBURG—Lawrence
LOUISA—Lawrence
WILLIAMSON—Mingo

Louisiana
BELLE ISLE*—St. Mary
CHENIERE AU TIGRE*—Vermilion
COMITE—East Baton Rouge
FORDOCHE*¹—Pointe Coupee
JACKSON—East Feliciana
JEANERETTE*¹—Iberia
PECAN ISLAND*—Vermilion
SCOTLANDVILLE—East Baton Rouge
WHITE CASTLE—Iberville

Louisiana-Mississippi
BATCHELOR*¹—Pointe Coupee

Maine
ASHLAND*¹—Aroostook
FORT FAIRFIELD NW—Aroostook
TELOS LAKE*—Piscataquis

Maryland
CATOCTIN FURNACE¹—Frederick
CENTREVILLE¹—Queen Annes
FINKSBURG¹—Carroll
GALENA¹—Kent
LANGFORD CREEK¹—Kent
NORTH EAST—Cecil
SWAN POINT¹—Kent
WOODSBORO¹—Frederick

Maryland-Pennsylvania-West Virginia
CUMBERLAND†—Allegany

Maryland-Delaware
MILLINGTON¹—Kent
SUDLERSVILLE¹—Queen Annes

Massachusetts
BARRE¹—Worcester
GRAFTON¹—Worcester
MARLBORO¹—Middlesex
MILFORD¹—Worcester
PETERSHAM¹—Worcester
WARE¹—Hampshire

Massachusetts-Connecticut
WEBSTER¹—Worcester

Massachusetts-Rhode Island
UXBRIDGE¹—Worcester

Michigan
DENTON—Wayne
FIBRE—Chippewa
FLETCHER*²—Kalkaska
GRAYLING*²—Crawford
MUNUSCONG—Chippewa
MUNUSCONG NE—Chippewa
PICKFORD—Chippewa
PICKFORD NW—Chippewa
RUDYARD—Chippewa

Minnesota
ADOLPH—St. Louis
ALBORN—St. Louis
ARNOLD—St. Louis
BROOKSTON—St. Louis
COHASSET EAST—Itasca
COHASSET WEST—Itasca
CROOKSTON*—Polk
DULUTH—St. Louis
DULUTH HEIGHTS—St. Louis
FREDENBERG—St. Louis
FRENCH RIVER—St. Louis
GRAND RAPIDS—Itasca
IVERSON—Carlton
KNIFE RIVER—Lake
MORGAN*—Redwood
SAGINAW—St. Louis
SISEEBAKWET LAKE—Itasca
THOMPSON LAKE—St. Louis

Minnesota-South Dakota
ORTONVILLE*—Big Stone

Minnesota-Wisconsin
LAKEWOOD—St. Louis

Mississippi
McCARLEY*—Carroll
OAKLAND*—Yalobusha

Missouri
SILEX*—Lincoln

Missouri-Illinois
CHARLESTON*¹—New Madrid

Montana
LOMA WEST—Chouteau
PILOT ROCK—Chouteau
STRANAHAN—Chouteau
TUNIS—Chouteau

Nebraska
ASHBY*—Grant

Nevada
BRISTOL RANGE SE—Lincoln
EUREKA*—Eureka
OVERTON BEACH*—Clark
PINTO SUMMIT*—Eureka
PIOCHE—Lincoln
SPRUCE MOUNTAIN*—Elko
SPRUCE MOUNTAIN 4*—Elko

Nevada-Arizona
GOLD BUTTE*—Clark
HOOVER DAM*—Mohave
ICEBERG CANYON*—Clark
VIRGIN BASIN*—Mohave

New Jersey
ATLANTIC CITY—Atlantic
FREEHOLD¹—Monmouth
HACKETTSTOWN—Warren
MARMORA—Cape May
OCEANVILLE—Atlantic
SEA ISLE CITY—Cape May

New Mexico
ALAMOGORDO*—Otero
ARROYO DEL AGUA—Rio Arriba
AZTEC BASIN—Santa Fe
BENAVIDEZ RANCH—Bernalillo
BERNALILLO NW—Sandoval
BLACKTOP MOUNTAIN*—Socorro
CANADA—Sandoval
CANJILON—Rio Arriba
CANJILON SE—Rio Arriba
CANONCITO SCHOOL—Bernalillo
CHILILI—Bernalillo
CUNDIYO—Santa Fe
ECHO AMPHITHEATER—Rio Arriba
EDGEWOOD—Santa Fe
EL RITO—Rio Arriba
GHOST RANCH—Rio Arriba
GLORIETA—Santa Fe
HERRERA—Bernalillo
JAROSA—Rio Arriba
KAYLOR MOUNTAIN*—Socorro
LAGUNA PEAK—Rio Arriba
LA MADERA—Rio Arriba
LA MESITA NEGRA SE—Bernalillo
MAGOTE PEAK—Rio Arriba
McCLURE RESERVOIR—Santa Fe
MESCALERO*—Otero
MILBOURN RANCH—Torrance
SALINAS PEAK*—Socorro
SAN PEDRO—Sante Fe
SANTA ANA PUEBLO—Sandoval
SIERRA BLANCA PEAK*—Otero
SIERRA MOSCA—Sante Fe
SKY VILLAGE—Sandoval
SKY VILLAGE SE—Sandoval
SOUTH GARCIA—Bernalillo
SOUTH GARCIA SE—Valencia
TESUQUE—Santa Fe
TRAMPAS—Taos
TRUCHAS—Rio Arriba
VOLCANO RANCH—Bernalillo
YOUNGSVILLE—Rio Arriba

New York
ADDISON—Steuben
ALCOVE—Albany
AVERILL PARK—Rensselaer
AVOCA—Steuben
BARTON—Tioga
BEAVER DAMS—Chemung
BIG FLATS—Chemung
BRADFORD—Steuben
CORNING—Steuben
EAST CHATHAM—Columbia
GENEVA SOUTH—Ontario
HORSEHEADS—Chemung
ITHACA WEST†—Tompkins
LEEDS—Greene
LYONS—Ontario
NORTH WOLCOTT—Wayne
RHEIMS—Steuben
ROSE—Wayne
SAVANNAH—Wayne
SAVONA—Steuben
SODUS POINT—Wayne
WEST CHICO BEACH¹—Suffolk
WINDSOR—Broome

North Carolina
BROWNS INLET—Onslow
BUFFALO CITY—Dare
CHADBOURN*—Columbus
ENGLEHARD NW—Hyde
NEW RIVER INLET—Onslow
OREGON INLET—Dare
SPICER BAY—Onslow

Ohio
BATAVIA—Clermont
BURTON—Geauga
CHAGRIN FALLS—Geauga
CHESTERLAND—Geauga
CLEVELAND NORTH—Cuyahoga
EASTLAKE—Lake
GRAFTON—Lorain
LAKEWOOD—Cuyahoga
MADIERA—Hamilton
MEDINA—Medina
MENTOR—Lake
NEWTONSVILLE—Clermont
NORTHFIELD—Summit
NORTH OLMSTED—Cuyahoga
PENINSULA—Summit
WEST RICHFIELD—Summit
WILLIAMSBURG—Clermont

Ohio-Indiana-Kentucky
HOOVEN—Hamilton

Ohio-Kentucky
FELICITY—Clermont
IRONTON—Lawrence
WITHAMSVILLE—Clermont

Ohio-Kentucky-West Virginia
CATLETTSBURG—Boyd

Oregon
CLATSOP SLIT—Clatsop

Pennsylvania
BADEN—Beaver
CANONSBURG—Washington
EMSWORTH—Allegheny
GLENSHAW—Allegheny
HACKETT—Washington
MARS—Butler
MERCERSBURG*²—Franklin
NEW KENSINGTON WEST—Westmoreland
OAKDALE—Allegheny
OXFORD—Chester
PARKESBURG—Chester

Puerto Rico
MANATI[1]—Manati

Rhode Island
HOPE VALLEY[1]—Washington

South Dakota
BLACKHAWK—Meade
BOXELDER—Pennington
CAPUTA—Pennington
CAPUTA NE—Pennington
CAPUTA SW—Custer
FOLSOM—Custer
FORT MEADE—Meade
FORT MEADE NE—Meade
FORT MEADE SE—Meade
HEREFORD SW—Meade
HERMOSA—Custer
HERMOSA NE—Pennington
HERMOSA NW—Pennington
HERMOSA SE—Custer
NEMO—Lawrence
NEW UNDERWOOD—Pennington
PIEDMONT—Meade
RAPID CITY EAST—Pennington
RAPID CITY NW—Meade
RAPID CITY WEST—Pennington
SILVER CITY—Pennington
STURGIS—Meade
TILFORD—Meade

Tennessee
BURRVILLE—Morgan
GRIMSLEY—Fentress

Tennessee-Kentucky
JELLICO EAST—Campbell

Texas
BERRY SAND DRAW—Potter
BOLING—Wharton
BORGER—Hutchinson
OTEY—Brazoria
THOMPSONS—Fort Bend

Utah
CAVE CANYON—Beaver
DUGWAY RANGE NW—Tooele
FIREWATER CANYON*—Uinta
HITE*—Garfield
MILFORD FLAT—Beaver
MINERSVILLE—Beaver
TOPAZ MOUNTAIN*—Juab

Virginia-North Carolina
SOUTH BOSTON*—Halifax

Washington
ANDERSON ISLAND*—Pierce
ANGELES POINT—Clallam
BALD KNOB*—Ferry
BOTHELL—King
BREMERTON WEST—Kitsap
CARNATION—King
CASTLE ROCK*—Cowlitz
CORRAL CANYON—Benton
COUPEVILLE*—Island
COYOTE RAPIDS*—Benton
CUMBERLAND—King
DISQUE—Clallam
EDIZ HOOK—Clallam
EDMONDS EAST—Snohomish
ELWHA—Clallam
FALL CITY—King
FREELAND—Island
GARDINER—Jefferson
GIG HARBOR—Pierce
GRAND COULEE DAM*†—Okanogan
HANFORD*—Benton
HOBART—King
HOLLY—Kitsap
HURRICANE HILL—Clallam
JOYCE—Clallam
LAKE CRESCENT—Clallam
LAKE JOY—King
LAKE SUTHERLAND—Clallam
LAKE WOOTEN—Mason
MALTBY—Snohomish
MONROE—Snohomish
MOUNT MULLER—Clallam
MUKILTEO—Snohomish
NORTH BEND—King
OLALLA—Kitsap
PE ELL*—Lewis
PIGEON SPRINGS—Cowlitz
PORT ANGELES—Clallam
RICHLAND*—Benton
SEVENTEENMILE MOUNTAIN*—Ferry
SNOHOMISH—Snohomish
SNOQUALMIE—King
SULTAN—Snohomish
TWIN RIVERS—Clallam

Washington-Oregon
SKAMOKAWA*—Wahkiakum

Wisconsin
CLOVERLEAF—Douglas

West Virginia-Kentucky
NAUGATUCK—Mingo

Wyoming
ANDERSON RIDGE—Fremont
BRADLEY PEAK—Carbon
BUZZARD RANCH—Carbon
FERRIS—Carbon
LEWISTON LAKES—Fremont
MOUNT ARTER—Fremont
PATHFINDER RESERVOIR SW—Carbon
RAWLINS—Carbon
RED CANYON—Fremont
RIDDLE CUT—Carbon
SCHLICHTING MOUNTAIN—Fremont
SEMINOLE DAM SE—Carbon
SEMINOLE DAM SW—Carbon
SOUTH PASS CITY—Fremont
THE Q RANCH—Carbon
WILD HORSE MOUNTAIN—Carbon

In addition to the standard series of quadrangle maps, small-scale (1:250,000) maps of areas in the United States and Territories are being published and distributed. Some of these maps are published in a shaded-relief edition, as indicated in the list below. They may be purchased from the Geological Survey for 50 cents per copy. An index to the series is available on request.

Arizona-New Mexico-Mexico
DOUGLAS

California
LOS ANGELES†

Connecticut-New York
HARTFORD†

Public Land Survey Plats

THE FOLLOWING plats of public land surveys and resurveys were completed and accepted by the Bureau of Land Management, U. S. Department of Interior, between March 1 and May 31, 1955. The class or purpose of the survey is indicated. Copies of the plats may be secured from the Bureau offices in the States or from the Director, Bureau of Land Management, Department of the Interior, Washington, D. C.

Alaska
Fish Creek Unit No. 2 Group—U. S. Survey 3281
North Pelican Group—U. S. Survey 3371
NW Addition, Townsite of Sitka—U. S. Survey 3303
Thimbleberry Bay Group—U. S. Survey 3302

Alaska—Seward Meridian
T. 15 N., R. 1 W.—Subdivision of sections

Alaska—Fairbanks Meridian
T. 9 S., R. 10 E.—Subdivision of sections

Arizona—Gila and Salt River Meridian
T. 5 N., R. 18 W.—Original survey
T. 6 N., R. 18 W.—Original survey
T. 6 N., R. 19 W.—Original survey
T. 6 N., R. 20 W.—Extension survey
T. 7 N., R. 18 W.—Original survey
T. 7 N., R. 19 W.—Extension survey
T. 7 N., R. 20 W.—Extension survey
T. 7 S., R. 15 W.—Subdivision of sections
T. 7 S., R. 16 W.—Subdivision of sections
T. 8 S., R. 15 W.—Subdivision of sections

T. 8 S., R. 16 W.—Subdivision of sections
T. 8 S., R. 18 W.—Subdivision of sections (5 plats)
T. 8 S., R. 19 W.—Subdivision of sections (2 plats)
T. 8 S., R. 20 W.—Subdivision of sections (2 plats)
T. 9 S., R. 23 W.—Tract survey—Fort Yuma Airport

California—Mount Diablo Meridian

T. 4 S., R. 36 E.—Dependent resurvey
T. 5 S., R. 37 E.—Dependent resurvey

California—San Bernardino Meridian

T. 2 N., R. 8 E.—Dependent resurvey

Idaho—Boise Meridian

T. 7 S., R. 23 E.—Subdivision of sections
T. 7 S., R. 24 E.—Subdivision of sections
T. 8 S., R. 23 E.—Subdivision of sections (4 plats)
T. 8 S., R. 24 E.—Subdivision of sections (3 plats)
T. 8 S., R. 25 E.—Subdivision of sections

Kansas—Sixth Principal Meridian

T. 14 S., R. 19 W.—Dependent resurvey
T. 14 S., R. 20 W.—Dependent resurvey
T. 14 S., R. 21 W.—Dependent resurvey
T. 15 S., R. 19 W.—Dependent resurvey
T. 15 S., R. 20 W.—Dependent resurvey

Montana—Principal Meridian

T. 2 N., R. 28 E.—Dependent resurvey
T. 2 N., R. 29 E.—Dependent resurvey
T. 2 N., R. 30 E.—Dependent resurvey
T. 2 N., R. 31 E.—Dependent resurvey
T. 3 N., R. 8 W.—Dependent resurvey
T. 4 N., R. 31 E.—Dependent resurvey
T. 4 N., R. 32 E.—Dependent resurvey
T. 4 N., R. 33 E.—Dependent resurvey
T. 5 N., R. 33 E.—Dependent resurvey
T. 5 N., R. 34 E.—Dependent resurvey
T. 6 N., R. 34 E.—Dependent resurvey
T. 6 N., R. 35 E.—Dependent resurvey
T. 6 N., R. 38 E.—Dependent resurvey
T. 6 N., R. 39 E.—Dependent resurvey
T. 6 N., R. 40 E.—Dependent resurvey
T. 6 N., R. 41 E.—Dependent resurvey
T. 6 N., R. 44 E.—Dependent resurvey
T. 7 N., R. 35 E.—Dependent resurvey
T. 7 N., R. 36 E.—Dependent resurvey
T. 7 N., R. 37 E.—Dependent resurvey
T. 7 N., R. 38 E.—Dependent resurvey
T. 7 N., R. 51 E.—Island survey
T. 17 N., R. 20 E.—Dependent resurvey
T. 17 N., R. 21 E.—Dependent resurvey
T. 19 N., R. 21 E.—Dependent resurvey
T. 21 N., R. 58 E.—Island survey
T. 27 N., R. 54 E.—Survey of accretions
T. 27 N., R. 56 E.—Survey of accretions
T. 32 N., R. 16 E.—Dependent resurvey
T. 5 S., R. 42 E.—Island surveys
T. 8 S., R. 40 E.—Subdivision of sections

Nevada—Mount Diablo Meridian

T. 3 S., R. 36 E.—Original survey
T. 4 S., R. 35 E.—Original survey
T. 4 S., R. 36 E.—Original survey

New Mexico—New Mexico Principal Meridian

T. 2 N., R. 4 W.—Dependent resurvey
T. 30 N., R. 13 W.—Dependent resurvey

North Dakota—Fifth Principal Meridian

T. 136 N., R. 84 W.—Dependent resurvey
T. 136 N., R. 85 W.—Dependent resurvey
T. 136 N., R. 86 W.—Dependent resurvey
T. 136 N., R. 87 W.—Dependent resurvey
T. 136 N., R. 88 W.—Dependent resurvey
T. 137 N., R. 84 W.—Dependent resurvey

Oregon—Willamette Meridian

T. 23 S., R. 40 E.—Dependent resurvey
T. 23 S., R. 41 E.—Dependent resurvey
T. 24 S., R. 40 E.—Dependent resurvey
T. 24 S., R. 41 E.—Dependent resurvey
T. 34 S., R. 4 W.—Dependent resurvey

Utah—Salt Lake Meridian

T. 16 S., R. 13 E.—Skeleton survey
T. 18 S., R. 13 E.—Skeleton survey
T. 19 S., R. 13 E.—Skeleton survey
T. 22 S., R. 1 E.—Dependent resurvey
T. 26 S., R. 11 E.—Skeleton survey
T. 26 S., R. 14 E.—Skeleton survey
T. 28 S., R. 8 E.—Skeleton survey
T. 28 S., R. 14 E.—Skeleton survey
T. 28 S., R. 15 E.—Skeleton survey
T. 28 S., R. 16 E.—Skeleton survey
T. 28 S., R. 17 E.—Skeleton survey
T. 28 S., R. 21 E.—Skeleton survey
T. 29 S., R. 15 E.—Skeleton survey
T. 29 S., R. 16 E.—Skeleton survey
E. 29 S., R. 17 E.—Skeleton survey
T. 29 S., R. 21 E.—Skeleton survey
T. 29½ S., R. 22 E.—Skeleton survey
T. 30 S., R. 16 E.—Skeleton survey
T. 30 S., R. 22 E.—Skeleton survey
T. 33 S., R. 6 E.—Skeleton survey
T. 33 S., R. 7 E.—Skeleton survey
T. 34 S., R. 6 E.—Skeleton survey
T. 34 S., R. 7 E.—Skeleton survey
T. 35 S., R. 6 E.—Skeleton survey
T. 35 S., R. 7 E.—Skeleton survey

Washington—Willamette Meridian

T. 14 N., R. 14 E.—Original survey
T. 33 N., R. 39 E.—Dependent resurvey

Wyoming—Wind River Meridian

T. 3 N., R. 2 E.—Subdivision of sections (2 plats)
T. 3 N., R. 3 E.—Subdivision of sections
T. 3 N., R. 6 E.—Subdivision of sections (2 plats)
T. 4 N., R. 2 E.—Subdivision of sections (3 plats)
T. 4 N., R. 3 E.—Subdivision of sections (5 plats)

Wyoming—Sixth Principal Meridian

T. 57 N., R. 97 W.—Subdivision of sections

Lake Survey Charts

PUBLICATION of new editions of the following Lake Survey Charts has been announced by the United State Lake Survey of the Corps of Engineers, U. S. Army. Copies of these charts may be obtained from the U. S. Lake Survey, 630 Federal Bldg., Detroit 26, Mich., at 75 cents per copy. Payment is required in advance by P. O. money order or draft, payable to the Treasurer of the United States.

0.—General chart, including Lake Champlain and New York canals at 1:1,200,000 scale. (April 1955.)

6.—Straits of Mackinac, False Detour Channel and Presque Isle, Mich., to Point Epoufette, Mich., and Little Traverse Bay, Mich., at 1:120,000 scale. (April 1955.)

9.—Lake Superior, general chart of the entire lake at 1:500,000 scale. (May 1955).

43.—St. Clair River, including St. Clair Flats and foot of Lake Huron at 1:40,000 scale, with inset of head of St. Clair River at 1:15,000 scale. (May 1955.)

66.—Inland Route, Michigan, from Cheboygan, Mich., to Little Traverse Bay, at 1:40,000 scale, with inset of Cheboygan Harbor, Mich., at 1:15,000 scale. (March 1955.)

94.—Coast chart, Big Bay Point, Mich., to Redridge, Mich., including Keweenaw Peninsula and Keweenaw Waterway at 1 : 120,000 scale, with insets of Eagle Harbor, Mich., and Copper Harbor, Mich., at 1 :15,000 scale. (April 1955.)

95.—Coast chart, Redridge, Mich., to Little Girls Point, Mich., at 1 : 120,000 scale, with inset of Ontonagon, Mich., at 1 :10,000 scale. (May 1955.)

97.—Coast chart, Beaver Bay, Minn., to Pigeon Point, Minn., at 1 : 120,000 scale, with inset of Grand Marais, Minn., at 1 : 10,000 scale. (May 1955.)

524.—Saginaw River, Mich., entire river and entrance channel to Saginaw Bay at 1 : 20,000 scale. (February 1955.)

601.—Les Cheneaux Islands, Mich., at 1 : 20,000 scale. (May 1955.)

725.—Head of Green Bay, Wis., and Fox River below DePere, Wis., at 1 : 25,000 scale, with inset of part of Green Bay, Wis., at 1 : 10,000 scale. (February 1955.)

931.—Grand Island, Mich., including coast from Sail Rock to Au Train Point, Mich., at 1 : 30,000 scale, with inset of Minising Harbor, Mich., at 1 : 15,000 scale. (April 1955.)

943.—Keweenaw Bay, Mich., at 1 : 30,000 scale, with insets of L'Anse, Mich., and Pequaming, Mich., at 1 : 10,000 scale. (February 1955.)

Airborne Surveying for Uranium

THE FOLLOWING material is quoted from an address given by Royale S. Foote, Chief, Geophysical Exploration Branch, Atomic Energy Commission, at the Mining Show, American Mining Congress, San Francisco, September 1954, as printed in *Mineral Information Service*,* Vol. 8, No. 4, April 1, 1955.

Uranium ore on the ground can be located from the air by detecting the radiation that is always given off by natural uranium ore . . . . Airborne surveying can result in the detection and location of outcropping uranium ore only if the outcrop is large enough or high enough in grade. The actual size and grade that can be detected depends upon the altitude of the survey, the speed at which the aircraft flies, and the type of instrumentation utilized. At 100 feet or less with proper technique, a survey should be able to detect an outcrop several hundred square feet in area of an average grade of 0.1 percent U_3O_8. Generally speaking, a smaller area can be detected if the grade is higher.

Certain other factors must be considered in the evaluation of the technique. Production of radiation is not unique to uranium ore. There is radiation present at any location on the earth and what we look for is an increase in rate of radiation and not just the detection of radiation. The indication of natural radiation by an instrument is called the background reading and all indications of additional radiation or "anomalies" are measured in terms of increase over the background reading.

There must be enough uranium ore outcropping at the surface to supply enough radiation for a reasonable increase. The ore must be exposed at the surface (for all practical purposes) because a foot or so of barren overburden will render undetectable the gamma radiation from the ore beneath it.

It is necessary to fly close to any outcrop or above any area because the radiation given off by uranium decreases in intensity as you get farther away from it. Flying at altitudes above 500 feet, many small areas of mineralization will not be detected even with the best instruments. Outcrops that are detected at or above 500 feet will be difficult to locate on the ground and difficult to partially evaluate by an observer from the air.

The most effective and economic airborne surveying is run with small highly maneuverable aircraft flying close to the outcrop area. The closer it is possible to approach the outcrop, the more anomalies will be detected, and for low altitudes it is best to fly as slowly as is safe. Flying at 50 feet above the ground, the ground speed should be kept around 65–75 miles per hour. The amount of coverage or the area that will be scanned on the ground from a certain altitude can be estimated by assuming that the width of a path covered on the ground will be twice the altitude at which the aircraft is flying; thus, flying at 100 feet, a path on the ground approximately 200 feet wide would be within the range of detectability.

To get full advantage of the airborne surveying techniques, an experienced geologist should do the observing from the aircraft. He should be familiar with the geology in the area under consideration and after a short period of training in flight should be very effective in guiding the survey and in applying geologic judgment during flight as to which outcrops might be followed.

* Published by the Division of Mines, Department of Natural Resources, State of California.

Comment and Discussion

The pages of SURVEYING AND MAPPING are open to a free and temperate discussion of all matters pertaining to the interests of the CONGRESS. It is the purpose of this Department to encourage comments on published material or the presentation of new ideas in an informal way.
—EDITOR

GEOCARTOGRAPHY

J. S. KEATES*—The stimulating note "Topocartographers and Geocartographers" by Prof. Raisz in the January–March 1955 issue of SURVEYING AND MAPPING spoke eloquently of the feelings of many of us engaged in commercial small-scale mapping. While we accept the fundamental importance of survey and official large-scale mapping programs, we envy the scientific exactitude of specific assignments which helps so much to give the "topocartographer" his recognized professional status.

The problems of geocartography have reached a new stage with the emergence of a recognized division between map editing and compilation, and the reproduction process. Even in the European companies where the tradition of the personal craftsman is strongest, the trend is now towards a distinction between editing, drafting, and reproduction, even though the executive cartographer must plan the work through all stages.

Most of us in such a position have surely realized (and resented) the fact that the requirements for this type of work are so often misunderstood, and its functions are frequently ignored. Primarily engaged in making maps which draw on a wide variety of statistical and other information produced by recognized specialists, we hover uncertainly on the fringe of both geography and "topocartography," accepted by neither.

Many commercial organizations partly or occasionally involved in small-scale map reproduction are quite aware that the technical side of such work must be left to specialists. Yet they are often sublimely unaware that the presentation and content of such maps need equally specialist treatment before they reach the production stage. The publishing house which "sends out" its work to a free-lance artist, vaguely hoping that the result will be what the author wants, is a typical case of this.

The cartographic editor, or "geocartographer," must have a wide geographical background, with a genuine interest in what goes on in the world. One of his primary problems is to keep abreast of all those minor changes which are continually being enacted all over the globe: the results of new survey, economic developments, and changes in human distributions. Not only must he be familiar with such information, but he must use judgment and experience in selecting what is relevant to his project.

Allied to this he needs an adequate technical knowledge of drafting and reproduction process, a flair for graphic presentation, and executive and organizational ability to coordinate his work through its various stages. Moreover, both the contents and reproduction must be judged against a strict background of costs and market requirements.

All this adds up to a great deal in human skill and experience. The genuine cartographer is fundamentally aware that his production, whether a large colored sheet or a small bookmap, must faithfully interpret the area or subject as accurately as possible, keeping the map user up to date with recent developments and warning him where information is inadequate or unreliable.

It is along those lines that the geocartographer makes his claim to professional recognition, for the interpretation of much scientific work is presented by him to the general public.

With regard to this I would like to make two proposals: first, that we should attempt to create some sort of international organization, both to promote ideas of common interest and to educate those joining our profession; and, second, to establish some kind of postal "bureau" through which requests for information or criticism could be passed on to someone "on the spot." Much of the editorial work in small-scale mapping is a matter of judgment, and surely we could all improve our work by submitting it for criticism to a cartographer living

* Cartographic Editor, Penguin Books Ltd., West Drayton, Middlesex, England.

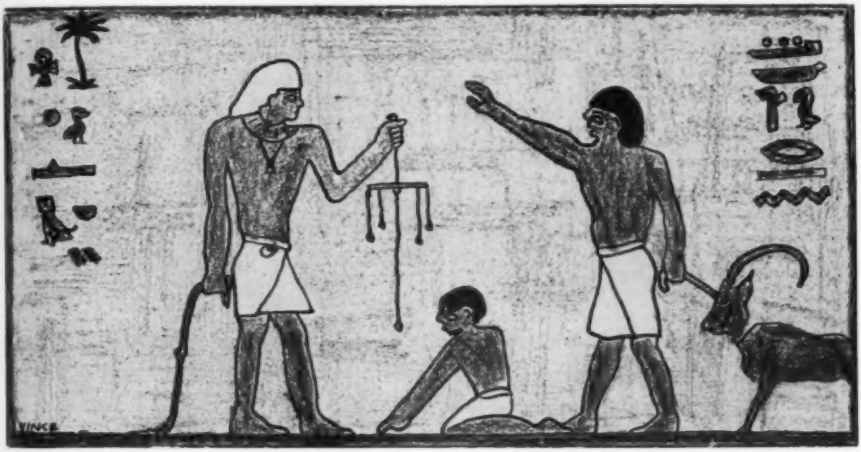
in, or familiar with, the area concerned.

So much is happening in the world today that no one team can hope to keep on top of all the changes that take place, particularly as many of them are unrecorded in the normal reference materials, or take a great length of time to obtain recognition. To quote Prof. Raisz, "To act wisely we have to learn a great deal about other countries and other people, . . ." and toward achieving this we could surely begin by mutual cooperation among ourselves.

SURVEYING IN ANCIENT EGYPT

VINCE KARLINER*—Enclosed find cartoon in style of Egyptian wall drawings. It has occurred to me that surveyors have had troubles of this sort ever since the days of the groma and knotted cord, which the gentleman on the left is holding.

* P. O. Box 477, Brawley, Calif.



"I don't care what you say, that tree is the corner and I defy you to change it!"

IS THE SEA LEVEL DATUM FOR STATE COORDINATE SYSTEMS NECESSARY?

The following exchange of letters between a private surveyor in Ohio and the U. S. Coast and Geodetic Survey presents differing views on a debatable question. Further comments from readers of SURVEYING AND MAPPING are invited.—EDITOR

GEORGE M. PACE*—As a private surveyor, I am interested in tying land surveys to the Ohio Coordinate System. In reading your Special Publication No. 235, I note that corrections are to be made for sea-level lengths and grid lengths.

Since grid corrections are already within a 1 to 10,000 limit of error, it seems to me that they are unnecessary for land surveys which are of a lower order in regard to error of closure. I feel that ordinarily, in suburban areas, 1 to 3,000 is all that is required on rough, wooded terrain with steep slopes, and 1 to 6,000 on gently rolling or level, open country.

With regard to paragraph 43 of your publication, I can not understand why State coordinate systems necessarily are placed on a sea-level datum. It seems to me that a datum referenced 700 feet above sea level, or thereabouts, for Ohio would eliminate any need for a sea-level or similar correction by private surveyors.

* Letter from George M. Pace, 7083 Paddison Road, Cincinnati 30, Ohio, to the Director, U. S. Coast and Geodetic Survey.

It is my opinion that every State coordinate system is an individual problem and that a common datum of elevation for all is not realistic in view of the wide differences in elevation in different parts of the country.

I believe that, in order to achieve maximum use of the State coordinate systems, the procedure for tying to the systems should entail no corrections at all by private surveyors except in unusual circumstances.

Your comments with regard to (1) the elimination of grid corrections, and (2) the elimination of sea-level corrections, by adjustment of the datum elevation, would be appreciated.

ROBERT W. KNOX†—I have read with interest your letter of Dec. 23, 1954, which discusses the possible elimination of corrections for scale and elevation in computing land surveys on the Ohio Coordinate System. Admittedly, if the accuracy you require is only 1 part in 3,000, there is not much point in correcting for scale error which, in the Ohio South Zone, never exceeds about 1 part in 16,000.

I do not agree that we should not base all our State coordinate systems on sea-level datum. All our triangulation has been computed on this datum which means that when the geographic positions are converted to coordinates these are automatically on the same datum. Theoretically, to raise the datum for each of the State zones to an average elevation of that zone would require that we recompute our triangulation which obviously is utterly impossible. As an alternative, we could recompute the plane coordinates by an approximate method to raise them to the different elevation planes, but this would lead to endless confusion along the zone boundaries. Ohio consists generally of a relatively flat terrain, but in other States, such as California, the range in elevation is so great as to preclude the idea of an average-elevation datum on that basis alone.

We believe that the reduction for scale and elevation is so simple that it should not be overlooked in all cases where it could appreciably help the survey closures.

I am inclined to agree with you that it would not be economical for private surveyors to extend survey ties beyond two thousand feet or so. A large surveying organization might find it profitable to put in a precise survey net of its own in order to place property surveys on the State systems, particularly in cases where a large subdivision development can be anticipated.

This letter should not be considered as one of criticism whatsoever; it merely reflects some of our thinking which, after all, involves only matters of opinion. We greatly appreciate letters such as yours which indicate an interest in tying surveys to the State coordinate systems as well as some good reasoning in shortcutting when this can be done.

† Letter from the Assistant Director, U. S. Coast and Geodetic Survey, to George M. Pace.

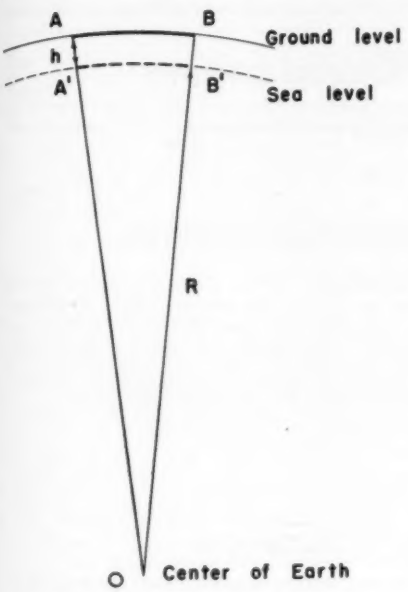
GEORGE M. PACE*—In reference to your letter dated January 3, 1955, I would like a further expression of opinion from other interested parties. In that connection, I would like your permission to publish our exchange of letters in the journal of the American Congress on Surveying and Mapping for the purpose of attempting to obtain the views of other private surveyors on this subject.

(NOTE: This permission was granted.—G. M. P.).

MR. PACE (to ACSM)—I do not, of course, advocate the recomputation of all U. S. Coast and Geodetic Survey triangulation. However, to amplify my thoughts in regard to the matter of making adjustments to precise traverses when establishing a network of State-coordinate monuments, a few pertinent comments will be expressed.

First, consider the case of a fully equipped survey party chaining distances between previously set concrete monuments. In this highly precise work chaining bucks are used, differences of elevation between the ends of the tape are observed, a spring balance measures the pull, the temperature is recorded, and the work is usually performed on a cloudy day. Perhaps more than one set of measurements is taken between monuments. At any rate, closures of 1 in 40,000 or better are obtained.

As an end result, a highly reliable distance measurement between the two monuments is obtained. Later, adjustments are made for closure, grid, and sea-level datum so that this very accurate distance, when published in a catalog of State-coordinate monuments, no longer appears as it was determined on the ground, but as an adjusted distance. To be sure, these adjustments are small and the first two are necessary beyond a doubt. However, I question the need for the sea-level datum adjustment in terrain where abrupt and excessive changes in elevation are not present.



For ready reference, figure 13, page 17 of USC&GS Special Publication No. 235 is reproduced here.

In the figure,

$$C = S\frac{h}{R+h},$$

where C is the correction to reduce the ground-level distance AB (or S) to the sea-level distance $A'B'$.

It is my opinion that the fewer the adjustments made to accurate field-measured distances, the better. In a State like Ohio, where the terrain is comparatively level, an adjustment to a datum approximately 700 feet below the ground level does not seem logical. My proposal is that the datum $A'B'$ be raised to coincide with AB, as nearly as practicable, thus making an adjustment for elevation unnecessary.

If this were the case, would an individual State datum for Ohio of 700 feet above sea level, or thereabouts, be a source of confusion near the State border where another State's system would overlap slightly? I think not, because any surveyor educated and progressive enough to be using the State coordinate system would certainly be careful enough to insure compatible coordinates and bearings. Furthermore, I do not think that it is necessary to use a different datum for every State. Certain States might be considered in a group; for example, Ohio, Indiana, and Illinois could, no doubt, use the same datum with a minimum of adjustments for elevation being required for public monuments and no adjustments at all for private surveys.

I realize that a datum system that would work for Ohio would not serve for Western States like Utah. I have no solution to propose for Utah, or Colorado, or California, or any of the Western States. Each State, or possibly a group of States, is an individual problem. Perhaps a sea-level datum with appropriate adjustments is best for the Western States, considering the terrain involved, but the matter should be investigated further.

Another disadvantage of changing the datum of the coordinate systems is that they have been in effect for a number of years and a change would lead to confusion as to which datum system was applicable in some cases. However, in many States the coordinate systems have been used very little to date. Therefore, if a change in datum is worthwhile, the sooner the better. In this connection, one reason why the State coordinate systems have not been used more is the impression of private surveyors that more calculations are required. To dispel that misgiving, I think we could well eliminate the sea-level correction in the great majority of cases, and, since the grid correction is already within an accuracy of 1 to 10,000, no correction at all would be necessary in ordinary surveying. In my opinion, the State coordinate systems have to be tailored to the needs of the ordinary land surveyor. The coordinate-system idea is a good one, but only if it is used.

In conclusion, I would like to say that I respect the gentlemen in the U. S. Coast and Geodetic Survey very much. My opinion differs from theirs on the matter of sea-level corrections for the State coordinate systems. However, it is not an acrimonious difference of opinion, and I am sure all of us have the same objective in mind.

My purpose in writing this discussion for SURVEYING AND MAPPING is to reach other surveyors throughout the country. If a few expressions of opinion on this subject, in the form of letters to the Editor, are forthcoming, they would, no doubt, prove very interesting and possibly very valuable for future developments.

News of Related Organizations

ASCE Executive Secretary Carey Retires

William N. Carey, Executive Secretary of the American Society of Civil Engineers for the past ten years, has retired from that office. Mr. Carey served the ASCE in many capacities dating from the time he became an associate member in 1916. For his outstanding work, the society presented Mr. Carey with a special plaque usually reserved for retiring Presidents.

The new Executive Secretary is William H. Wisely, well known in sanitary engineering circles, who has served as Associate Secretary of ASCE since the first of this year.

Wisconsin Society of Surveyors

The July 7, 1955, issue of the *Newsletter* of the Wisconsin Society of Land Surveyors reports that the long fight for legislation on registration of land surveyors of that State may be entering the final stage. The Legislative Committee announced that, after a rocky session in the legislature, the bill passed both houses of the legislature and was, at the time of the announcement, in the hands of the Governor for signature or veto.

Robert J. Poss, Chairman of the Legislative Committee, to whom is due much of the credit for the progress of the bill, made the thoughtful comment that passage of the bill puts every surveyor on his own to uphold the standards of the profession. "Dignity, accuracy, and care are more important now," he writes, "since each surveyor will reflect not only his own personal qualifications, but those of the profession as well." He pointed out, further, the necessity for surveyors to participate in surveying organization affairs in order to keep abreast of new developments in surveying law, in equipment, and in methods and procedures.

The Texas Surveyor

A new publication, devoted to surveying and mapping, made its appearance in July. Volume 1, Number 1 of the *Texas Surveyor* has been added to the growing list of publications devoted to the profession. The periodical, modest in size, features among other things a letter from President Fred Williamson announcing the appointment of a Texas State Board of Registration for Public Surveyors, which is to begin operations on September 6, and outlining the program of the Association for the ensuing year. In addition to various items pertaining to Association business there is an announcement of the July 29 meeting of the *Texas Section, American Congress on Surveying and Mapping.* Also published is what appears to be the start of an interesting department: "Surveying Wrinkles" and an article on "Texas Land Descriptions" by F. L. Dornier, Office Engineer of the Land Department, Shell Oil Company, Houston. Both features will be of interest to property surveyors. Future issues of the new publication will be awaited with interest.

CONGRESS NEWS

ACSM Report to National Research Council for Year Ending April 1955

Intensive efforts during the past year to promote increased interest and detailed attention to research phases of surveying and mapping reached a climax with the annual meeting held by ACSM in March 1955 jointly with the American Society of Photogrammetry. The meetings of the two groups ran consecutively with programs arranged to highlight matters of overlapping interest in one of the most comprehensive mapping expositions ever held.

The program for the Fifteenth Annual Meeting of the American Congress on Surveying and Mapping reflected the broad technical and professional scope of the society's membership. Panels and papers pertinent to the advancement and improvement of the technical sciences and professional practices in the field of surveying and mapping were presented. Among the feature papers was a discussion of the boundary problems raised by the Submerged Lands Act.

Representatives from nationally recognized organizations with kindred interest conducted a feature panel on the relationship existing between surveying, photogrammetry, and engineering. The principal objective of this panel was to promote the solution of problems common to all phases of surveying and mapping. This subject is a complex and controversial field involving such subjects as the professional status of surveyors, cartographers, and photogrammetrists; state registration laws and regulations; ethical practices; education and training; and other matters.

The six technical divisions of ACSM offered separate specialized programs, although selected division papers having general interest were featured in plenary sessions. The Education Division held joint meetings with ASP groups of similar interest for the purpose of coordinating summary findings in general session. The Control Surveys Division presented papers on electronics in modern surveying, and reports of measurement by light waves. The Property Surveys Division sessions were designed to stimulate interest among land surveyors and title men in problems of legal interpretation, custom, rights, fees, etc., and various land laws including those covering registration. The Topography Division presented papers on map use and the importance of maps to planning, large-scale topography by aerial methods, and other timely items. The Cartography and Instruments Divisions presented exhibits and papers having special appeal for those interested in new developments in surveying and mapping.

The year's work ended with a sense of satisfaction in the healthy condition of ACSM, as reflected in a growing membership, favorable financial condition, and active interest among local sections. Noteworthy developments in cartographic techniques were reported by agencies supporting ACSM. Among these were the solution to technical problems by the Air Force Aeronautical Chart and Information Center, listed as follows:

1. A photo-mechanical method of achieving a vignetted or feathered treatment of graded shades of blue for shoreline emphasis along coasts and for inland water features.
2. The Lac-Strip technique of color separations for preparing gradient tints used to indicate elevations on maps and charts.
3. A photo-mechanical solution for adjusting or toning down contour lines on photomaps so they will not obliterate essential information.

The President's ambitious highway-building program will afford opportunities for furthering the geodetic control networks of the United States. ACSM resolutions in this connection provide for the following:

1. The coordination of highway surveys with the established network of ground control surveys.
2. The preservation of survey monuments already established.

3. The establishment by the Coast and Geodetic Survey of permanent monuments, resulting from precise horizontal and vertical control surveys, at intervals of one or two miles along the proposed routes of the Interstate Highway Systems.

The use of Raydist, an electronic surveying system in which distances are determined in terms of phase shift, received considerable attention during the year. Measurements have been obtained over flat arid country with a degree of accuracy of one part in 100,000. Successful applications of Raydist are being made in surveying large over-water areas and difficult terrain, tracking of high-speed missiles and aircraft, and navigation and positioning.

The Geodimeter, an instrument capable of measuring distances using the velocity of light, is another highlight in the field of geodetic measurement. With this instrument, distance measurements are obtained by determining electronically the time interval required for a light beam to travel from the device to a distant reflector and return. The time interval is measured by a phase comparison technique not unlike the method employed in a conventional radar system in measuring the time lapse between transmission and reception of a pulse of electromagnetic energy.

—H. Arnold Karo
ACSM Representative

Northern and Southern California Sections Hold Joint Meeting

Well over one hundred persons attended the First Annual Joint Meeting of the Northern and Southern California Sections in Fresno, May 5–6–7, 1955.

Welcoming addresses were given William C. Meek and Charles A. Wooldridge, Jr., Chairmen of the two participating Sections. Prof. C. J. Aggeler, City College of San Francisco, discussed the adoption of the Lambert Coordinate Grid in California. His theme was: ". . . it is coming . . . sit back, relax, benefit, and enjoy it." Chuck Wooldridge described the East Bay Council setup, and explained how it is benefiting that area.

William White, State Board of Registration, gave an informal resumé of legislative activity in Sacramento. Curtis M. Brown of San Diego discussed "Property Transfers Without Written Conveyances." William C. Wattles of Los Angeles delivered an address on "Boundary Controls," stressing the ever present and always important factor: ". . . but the contrary may be shown!" V. S. Seward, U. S. Geological Survey, Sacramento, spoke on his agency's experience with scribing techniques.

Those surviving the dinner and dance Saturday night made the scheduled tour of inspection of the Fresno facilities of the Security Title Insurance Company before heading for home.

Tom R. Humes of the Surveyors Service Company, Los Angeles, was appointed chairman for next year's joint meeting, slated for May, in Santa Barbara.

—Tom R. Humes
Section Editor

PROMINENT ACSM MEMBERS GET TOGETHER AT THE FRESNO MEETING

Seated (*left to right*): William C. Wattles, National Vice President; William C. Meek, Chairman, Southern California Section. Standing (*left to right*): Willard Walker of Fresno; Charles A. Wooldridge, Jr., Chairman, Northern California Section.

Southern California Section Holds Drafting Clinic

More than 300 engineers and engineering draftsmen attended the "Drafting Clinic" sponsored by the Southern California Section, in the General Petroleum auditorium, Friday, April 1, 1955. The response was far greater than was anticipated and more than rewarded the local Section for the planning and effort that preceded the affair.

Living demonstrations, rather than cold exhibits, account for the success of the meeting. From 3 p.m. until 6 p.m. that evening, attendants and demonstrators at the six sections of the "Clinic" were kept busy explaining their specialties.

The highlight of the day, and the most popular feature in the show, was the demonstration of manuscript development by scribing, staged by T. J. Wadsworth of the U. S. Geological Survey, through the courtesy and cooperation of that organization.

Another display and practical demonstration that created considerable interest, was the development of polyconic and transverse Mercator projections, presided over by Roy Sylar of the U. S. Coast and Geodetic Survey. Closely allied with this, and competing with it for attention, was a demonstration of Lambert projections, staged by Selwyn Douglas of the General Petroleum Corporation.

Of considerable general interest were the colorful and extensive examples of color slide production, shown by John Asher, Chief Draftsman of the General Petroleum Corporation. Although not strictly a cartographic demonstration, this feature was popular because so many drafting departments in large organizations are frequently called upon to produce similar graphic presentations for other departments.

The photogrammetric display, featuring a Multiplex in actual use, was handled by Pafford, Jones & White. This section also vied with the others in commanding the attention of the visitors, as this was the first opportunity for many of them to witness such equipment in operation.

A demonstration of field-note interpretation, supervised by the Survey Division of the City of Los Angeles, also proved to be a popular item, as it provided a foundation for improved liaison between the draftsman and the field engineer.

The success of the entire affair makes it probable that a similar "Clinic" will be an annual event for the Southern California Section.

—Tom R. Humes
Section Editor

PART OF THE THRONG OF MEMBERS AND VISITORS WHO PARTICIPATED IN THE DRAFTING CLINIC STAGED BY THE SOUTHERN CALIFORNIA SECTION, ACSM, APRIL 1, 1955.

Louisiana Section

The regular quarterly meeting of the Louisana Section of the American Congress on Surveying and Mapping was held at the New Orleans Engineers' Club, DeSoto Hotel, New Orleans, on April 20, 1955. Sixty members and guests were present.

After a social hour, the meeting was called to order by Chairman Chapman. Mr. Chap-

man gave a brief report on ACSM's Fifteenth Annual Meeting, which was attended by eight members of the Louisana Section, and announced that the 1956 National Convention will be at the Shoreham Hotel, Washington, D. C., during March 1956.

George Mott, Treasurer, reported that there was a balance of $193.02 in the treasury.

A. L. Brawley, Membership Committee Chairman, reported that the present membership of the Louisiana Section was ninety members.

Mr. Slaughter of the Corps of Engineers, New Orleans District, presented an interesting talk on "Capture of the Mississippi River by the Atchafalaya—Closure of Old River" which was illustrated with slides.

Chairman Chapman expressed his thanks for the cooperation of all the officers and members during this tenure of office and announced the results of the election of officers as follows:

Jack S. Toler, *Chairman*
Martin Standard, *First Vice Chairman*
Harry Shutts, *Second Vice Chairman*
T. Baker Smith, *Third Vice Chairman*
George E. Mott, *Secretary*
George E. Jones, *Treasurer*

Directors

A. L. Brawley	1956
H. N. Harrison	1956
R. C. Dayton	1957
Robert Earle	1957
H. M. Hayne	1957

The Section assembled for another regular quarterly session on June 27, 1955, in the Engineer's Club, DeSoto Hotel, New Orleans.

Chairman Jack Toler opened the meeting with the introduction of the newly elected officers and directors.

Mr. Toler revealed that for the forthcoming year the Board of Directors had decided on an inaugural dinner for the installation of new officers in April.

As the evening progressed, Mr. Toler introduced Commander Robert Earle, Chief of the New Orleans office of the Coast and Geodetic Survey, who, in turn, presented the principal speaker, Lt. Comdr. Norman E. Taylor. Mr. Taylor is in charge of one of the two USC&GS parties currently engaged in reestablishing geodetic control along the Louisiana Gulf Coast and tying in numerous offshore oil structures. He showed a color movie which illusrated the erection of the ninety-foot Bilby steel observation tower, occupation of the tower by a party, measurement of a base line, and running a line of levels. Commander Taylor then outlined the scope and nature of the triangulation network now being performed. The barriers and complications encountered by his party in transporting and constructing their lofty towers in the soft, mucky marsh land was of utmost interest to the group. The speaker stated that the survey assignment was approaching completion and unadjusted copies of their computations could soon be obtained. After a question and answer session the meeting was brought to a close.

—GEORGE E. JONES
Secretary

Texas Section

The sixteenth meeting of the Texas Section of ACSM was held on March 30, 1955, in the Library Lecture Hall of the University of Houston, with 35 members and 9 guests present. R. L. Sargent, Chairman of the Section, presided.

Reports were given by the Treasurer, William J. Warren, on the financial status of the Section, and by ACSM National Director W. H. Wilson, on the Consecutive Meetings of the American Society of Photogrammetry and the American Congress on Surveying and Mapping in Washington.

E. D. Morse reported on the progress of the surveyors licensing bill. He announced that the bill had been favorably reported out of the House of Representatives and that an attempt would be made to obtain quick Senate approval.

W. G. Herzog, Chairman of the Program Committee, introduced the speaker of the evening: Robert O. Davis, Regional Engineer, Rocky Mountain Region, U. S. Geological Survey. Mr. Davis outlined recent developments in topographic mapping using the multi-lens aerial camera and improved stereophotogrammetric methods. He explained the use of helicopters by the Geological Survey for triangulation parties to facilitate coverage of vast and inaccessible areas in Alaska and Western United States. Mr. Davis accompanied his talk with appropriate slides and with an exhibit of maps in various stages of development.

The bill requiring the licensing of public land surveyors who practice in Texas was passed by

both the House of Representatives of Texas and the State Senate and was signed by Governor Shivers on April 29, 1955.

The bill provides that the Governor shall have ninety days in which to appoint a six-man board to administer the law and pass on applicants. After the board has been appointed, thirty days are to be allowed for the appointment of a chairman for the board and the performance of other duties necessary for the proper administration of the act.

Special credit for their efforts toward securing enactment of the law are due to E. D. Morse, Fred Williamson, and W. H. Wilson.

—Cecil J. Foster
Secretary, Texas Section

Obituary

PHILIP G. McCURDY

Philip G. McCurdy, Chief of Photogrammetry, U. S. Navy Hydrographic Office, passed away at George Washington University Hospital in Washington, D. C., on May 26, 1955, after an illness of several weeks. Mr. McCurdy entered the government service at the Hydrographic Office in 1931. In 1935 he served as hydrographic engineer on a Naval Survey Expedition to the Aleutian Islands and carried out pioneer photogrammetric assignments. He was placed in charge of photogrammetry in 1935, and developed the Hydrographic Office photogrammetric organization from a one-man team to its present status of 120 persons and diverse equipment and methods.

Mr. McCurdy was born at Sayreton, Alabama, August 14, 1901, and was educated in the public schools of Alabama. He was very active in scientific and technical societies and was a charter member of both the American Congress on Surveying and Mapping and the American Society of Photogrammetry. He was a Director, First Vice-President, President, and Honorary Member of the American Society of Photogrammetry, and also served that organization for many years as Editor of *Photogrammetric Engineering*. He was the Editor-in-Chief of the *Manual of Photogrammetry*, published in 1944, and for his outstanding work in this field he was awarded the American Society of Photogrammetry's Sherman Fairchild Award. For his service to the Department of Defense during World War II he received the Navy's Meritorious Civilian Award.

Mr. McCurdy served with the Corps of Engineers, U. S. Army, during World War I and remained in the Army until June 1925. During this period he was awarded a citation from the Chief of Engineers for outstanding topographic survey work. He later served as a consultant to commercial organizations in establishing photogrammetric training programs.

Mr. McCurdy was the author of *Manual of Photogrammetry, Hydrographic Office Pub. No. 591*, and *Manual of Coastal Delineation from Aerial Photographs, Hydrographic Office Pub. No. 592*. He is survived by his wife and three daughters.

Personals

Elmore K. Kerkela, production manager of Abrams Aerial Survey Corporation, Lansing, Mich., since 1953, has been made vice-president and manager of the firm.

Capt. Albert J Hoskinson, for the past 3 years Chief of the Geodesy Division, U. S. Coast and Geodetic Survey, retired on July 1, 1955, after an outstanding career of more than 34 years with that Bureau.

Captain Hoskinson made his main contribution to the Coast and Geodetic Survey in the field of geodesy. He made significant improvements in methods and techniques for making gravity observations, and was responsible for the design and construction of special instruments used in geodetic work. He is the author of two Special Publications of the Coast and Geodetic Survey on geodesy.

Besides being a member of numerous scientific and technical organizations, Capt. Hoskinson was the 1954 Chairman of the Control Surveys Division, ACSM, and is now President of the Geodesy Section of the American Geophysical Union.

Capt. Carl I. Aslakson, internationally known geodesist who retired recently from the U. S. Coast and Geodetic Survey, has joined the staff of Aero Service Corporation, Philadelphia. He will serve as a consultant in the use of Shoran and other electronic mapping techniques for the aerial mapping company.

Aslakson pioneered many applications of Shoran to surveying problems. His methods of computing Shoran positions, with the aid of IBM card-punched records, are greatly speeding Shoran mapping projects.

Prior to retirement, Aslakson served at Patrick Air Force Base for three years, surveying the Florida Missle Test Range for the Army, Navy, and Air Force. This proving ground extended over an 1,800-mile stretch of water from Cape Canavaral, Florida, to the Island of Trinidad. The Shoran survey covered all the islands of the Greater and Lesser Antilles and established island positions of the range within plus or minus 10 feet. Some island positions, fixed by older and less exact methods, proved to be in error by as much as 8 miles.

During his career of more than 30 years, Aslakson worked with mapping and geodetic control problems in the field in the Far East, in South and North America, and the Artic.

Capt. Aslakson's measurements of the speed of light, later verified by other observers, indicate a value about 10 miles per hour greater than the generally accepted 186,272 miles per hour. This work, and other geodetic studies, earned for Aslakson the Exceptional Service Medal of the U. S. Department of Commerce in 1953.

Ralph Moore Berry has been appointed Professor of Geodesy and Surveying at the University of Michigan, Ann Arbor, Mich. A graduate in civil engineering from the Catholic University of America, Washington, D. C., he was for many years chief of the Operations Branch, Division of Photogrammetry, U. S. Coast and Geodetic Survey, by whom he was granted a Department of Commerce Meritorious Service Award in 1954. For the past year and a half, he has been assistant to the director, USC&GS, on a special assignment to the office of the Assistant on Cartography, U. S. Bureau of the Budget.

Professor Berry is a registered professional engineer in the District of Columbia, and a registered professional engineer and land surveyor in Maryland. He is a member of the American Society of Photogrammetry and a member of the American Society of Civil Engineers in which he serves on the Committee on Surveys and Land Titles. He is a past-president of the Prince Georges-Montgomery Engineers Society (of Maryland).

A charter member of the American Congress on Surveying and Mapping, he served for ten years on the Annual Meeting Committee, was granted an Honorary Citation by the Congress in 1951, and was chairman of the Property Surveys Division from 1951 to 1953.

Dallas H. Watson, Atlantic Region Engineer, Topographic Division, U. S. Geological Survey, since 1946, retired on June 30, 1955.

Mr. Watson began work with the Geological Survey in 1911 and has been with that organization ever since except for service during World War I as an officer in the Coast Artillery in France.

Mr. Watson was succeeeded as Atlantic Region Engineer by Robert H. Lyddan.

Rear Admiral Robert F. A. Studds, who served ACSM as its President in 1953, retired as Director of the U. S. Coast and Geodetic Survey on August 1 after a lifetime of service in the Bureau.

Admiral Studds had held the important post of Director of the Coast and Geodetic Survey since May 1950. Under his leadership, many noteworthy accomplishments were made by the Bureau, including completion of the charting of the Gulf Intracoastal Waterway, development of a new series of aeronautical charts for use with the high-frequency omnirange naviga-

tional system, and cooperative development with the Naval Ordnance Laboratory of an airborne magnetometer for use over ocean areas.

In 1952 Admiral Studds was awarded the Department of Commerce Gold Medal for exceptional service to the Coast and Geodetic Survey for many years and for his outstanding leadership as its Director.

Rear Admiral H. Arnold Karo, formerly Chief, Division of Charts, has been appointed to succeed Admiral Studds as Director.

Northern California Section Holds Field Night

The Northern California Section, on the evening of June 24, 1955, held another of their popular field-night meetings. While designated as a field night, the meeting actually consisted of four parts: field demonstrations, equipment display, a talk and discussion on triangulation computations, and a movie.

Three fundamental aspects of surveying procedure were covered by the field demonstrations —precise taping and subtense-bar methods of distance determination; precise and differential methods of leveling with the Wye and dumpy levels; and methods and instruments for determining horizontal angles.

The meeting, which was open to the public as well as friends and guests of members of the Section, assembled after the demonstrations and the inspection of displays of manufacturers' instruments and special equipment developed by surveyors to hear a talk on simplification of triangulation computation by analytical methods and to view a movie on "The Manufacture and Use of Modern Surveying Instruments."

—H. A. WATERFALL
Secretary

PRE-CONVENTION JOURNAL

Advertising Tie-in Opportunity

The next Annual Meeting of the American Congress on Surveying and Mapping will be held in March, 1956.

The October–December issue of the JOURNAL will tie-in with the forthcoming Convention. Prepare to advertise your exhibit and products in this important issue to stimulate the interest of those potential buyers attending this event. From an advertising standpoint, this issue will be even more valuable because of the consecutive Annual Meetings of the American Congress on Surveying and Mapping and the American Society of Photogrammetry, March 18–24, 1956.

Exclusive advertising agency for the ACSM JOURNAL:

sba *SCHALER, BUTLER & ASSOCIATES*

Advertising—1616 EYE STREET, N.W., WASHINGTON 6, D. C.

• *Notice*

Sixteenth Annual Meeting, March 1956

The success of the 1955 ASP-ACSM Consecutive Meetings proved that the combined influence of two great conventions, closely associated in their fields of interest, offers greater attendance impact and appeal to the membership than any other previous meeting. Accordingly, the 1956 ACSM-ASP Consecutive Meetings are scheduled during the single week of March 18–24, with a mammoth Co-Exhibit in the spacious convention and exposition halls of the Shoreham Hotel, Washington, D. C.

Officers and committees of both societies are in full operation organizing outstanding programs worthy of the individual and overlapping interests of both memberships, in keeping with an expected attendance greater than the attendance of 1,664 in 1955.

Particular effort is being made to plan each day's program attuned in overlap of interest to preceding or following day, to afford every possible advantage in program continuity should it be necessary for travellers to select certain days for attendance.

A single registration is planned for the 1956 ACSM-ASP Consecutive Meetings for attendance at all or part of the ACSM 16th Annual Meeting or the ASP 22nd Annual Meeting Sessions.

Entertainment and social affairs of ACSM will be enjoyed together as programmed co-functions.

Exhibits will be on display from Monday noon, March 19, through Friday noon, March 23. The combined exhibits of leading companies from all parts of the world, and the displays by governmental mapping agencies from the United States, are worthy of attendance. It is of additional interest to ACSM regular Annual Meeting attenders to view the photogrammetric equipment displays and demonstrations. The observation of such machines and devices and the exchange of ideas with experts in the photogrammetric field proved of particular interest and benefit to the ACSM members in 1955.

Chairman William A. Radlinski of ASP 22nd and Chairman Franklin G. Williams of ACSM 16th, with wise counsel and advice from Honorary Chairman Robert H. Randall, are working toward early issuance of program information.

Early reports from the Program and Exhibits Committee indicate that great value can be received from the next March Annual Meetings——

the ACSM sessions March 19, 20, and morning of 21——

the ASP sessions from noon on March 21 through March 22 and 23, 1956.

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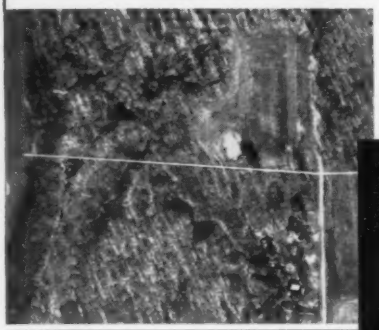

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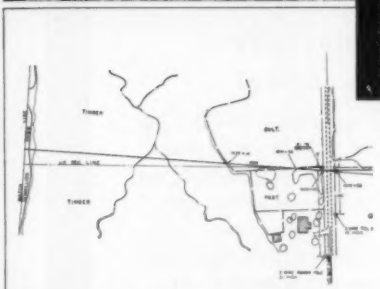

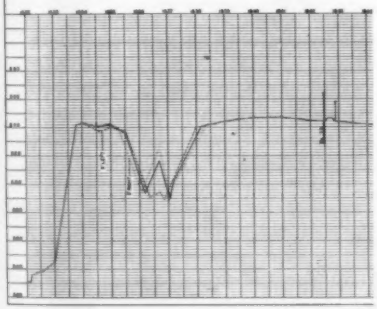

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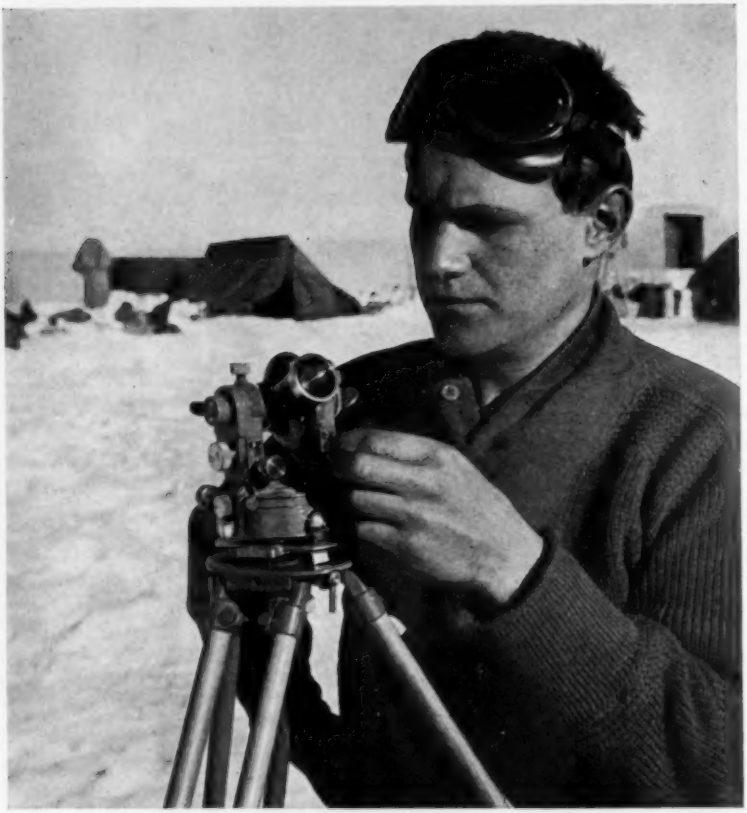

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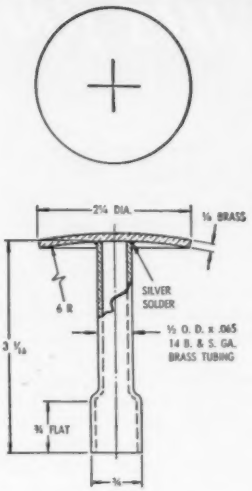

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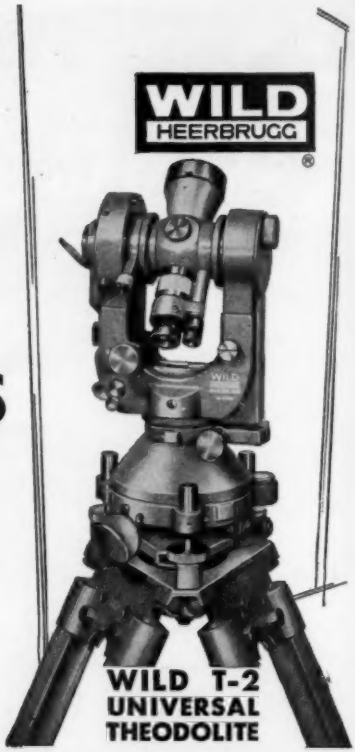

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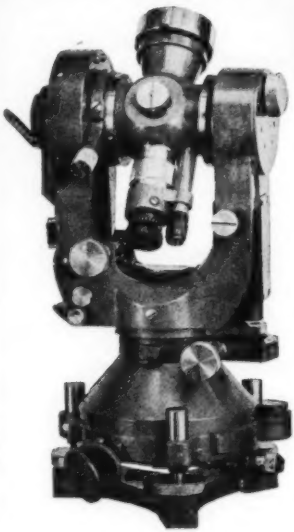

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